TEAGASC WALSH FELLOWSHIPS SEMINAR 2016

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ABSTRACTS

WALSH FELLOWSHIPS PROGRAMME

Teagasc

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Earlier this year Teagasc launched a new Foresight report, Teagasc Technology Foresight 2035. This report focuses on the identification of emerging technologies that will drive the competitiveness and sustainable growth of the Irish agri-food industry and bioeconomy sector over the next 20 years. Its goal is to identify new areas of technology in which Ireland needs to invest.

Earlier this year Teagasc launched a new Foresight report, *Teagasc Technology Foresight 2035.* This report focuses on the identification of emerging technologies that will drive the competitiveness and sustainable growth of the Irish agri-food industry and bioeconomy sector over the next 20 years. Its goal is to identify new areas of technology in which Ireland needs to invest.

A key conclusion is that the agri-food industry globally is on the verge of a revolution in the application of powerful new technologies. Increasingly rapid, recent advances in ICT and molecular biology, in particular, have the potential to transform the sector in the coming years. It is essential for the success of the Irish agri-food and related industries that Ireland is a central player in this revolution. Investment in new and existing technologies will play a decisive role in enabling the sector to sustainably intensify production and to grow output, exports and jobs, while respecting the environment.
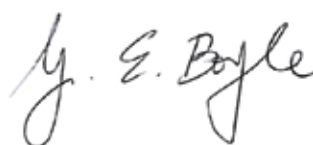
Technology will enable Ireland to demonstrate compliance with its legally binding obligations to protect the natural capital and reinforce its position as a clean-green producer. Harnessing this transformation will not only enable ambitious increases in the export of world-class agricultural produce, but will also drive the completion of a dynamic circular bioeconomy creating new jobs and new opportunities. It will help to increase profitability throughout agri-food value chains. It will drive exports of smart knowledge-based data-driven services, developed by Irish service providers, to markets in Europe, and across the globe.

Technological change over the next 20 years, whether it arises in the form of the adoption of new production techniques, new products or services or structural changes, will require changes in the stock of human capital throughout the value chain system. Producers will require to be more highly educated and skilled than ever before, not only to maximise profits from their businesses, but also to deal with a constantly changing set of sustainability and regulatory constraints. Farmers of the future will have to be entrepreneurial and to adopt a more business-like approach to their farms.

Our educational and training institutions will also have to adapt radically to respond to this requirement. Likewise, our food processing companies (dairy, meat and prepared consumer foods) will have to invest much more in their innovation capability, primarily through the recruitment of skilled scientists up to and including Ph.D. level. Our universities, institutes of technology and agencies like Teagasc will also have to be responsive to the innovation needs of industry.

Harnessing the power of new technologies will also require Teagasc to fill staff and expertise deficits in the areas of animal and plant genomics, in precision animal, grassland and crop agriculture and precision soil management, in modelling and data analytics, in microbiota as it relates to soil, animal and food applications, in advanced food technologies, and in value chain analysis and development. Addressing these deficits will allow the contribution of the technology areas to be harnessed in the areas of enhancing productivity and profitability, climate change, water quality, food innovation, etc.

The development and application of disruptive new technologies will require increasing investment and new approaches in the training of our PhD level human resources. The growing availability of high technology capital will speed up the creation of new products and production systems that will require workers to have greater cognitive skills and to be more adaptable and efficient learners. In addition, the globalisation of research and business activities means the ability to act in an internationally networked environment will assume ever greater importance. This makes PhD skills and attributes increasingly relevant.

Professor Gerry Boyle, Director

ORAL ABSTRACTS

Mining the *Lolium perenne* genome for a family of high affinity nitrate transporter genes

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As a critical soil-borne nutrient, nitrogen availability can have a great impact on the growth and yield of crop plants. Here we describe the generation of a gene-space assembly for *Lolium perenne* and its use in the phylogenetic study of a family of high-affinity nitrate transporter (HAT) genes involved in nitrate uptake under conditions of nitrate deprivation. Assembly was based on Illumina sequencing of paired-end, mate-pair and long-jumping distance libraries with insert sizes ranging from <300 bp to 40 kbp. A highly homozygous, tenth-generation, inbred line of *Lolium* was used as the source. Annotation was based on *ab initio* gene prediction, RNA-Seq, and comparison with existing gene models and transcripts for *Lolium* and related species. Using this assembly, a family of HAT genes was identified and subjected to more detailed phylogenetic analysis.A 1.11Gbp *de novo* assembly of the *Lolium* gene-space was generated, with scaffold N50 of 25,193 bp and contig N50 of 3,790 bp. *Ab initio* gene prediction, using a wheat-based model, identified 188,822 potential gene-like regions in the assembly. A broad-based RNA-Seq study identified 111,591 transcripts from 67,827 potential genes. Comparison with available gene model and transcript data sets for *Lolium* indicated that some 570 Mbp of the gene-rich portion of the genome had been captured. Mining for genes of interest indicated 11 members of the HAT family were present in *Lolium,* compared with 2 in rice, 3 in sorghum, 4 in *Brachypodium,* 10 in barley and up to 43 in wheat. A working draft assembly, capturing the bulk of the gene-space, was generated for *Lolium perenne* and, along with annotations has been made available as a JBrowse-based genome browser. A family of 11 root-specific HAT genes was characterised from this assembly and comparison with other *Poaceae* indicated that these genes are highly conserved, but with a highly variable copy number.

The microbial community dynamic in aggregate size fractions in grassland soils

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Soil organic carbon (SOC) is a critical component of agricultural soils as it supports many soil functions as well as acting as a sink for atmospheric carbon. Determining the soil microbial community composition at the soil aggregate scale may be a critical factor in understanding microbially mediated SOC cycling. This study aimed to determine the influence of both horizon depth and aggregate size fraction on the bacterial and fungal community composition across the soil profile in grassland soils. Soil samples were taken from the top 3 horizons down the soil profile from 9 grassland sites. Soils were physically fractionated to obtain the large macroaggregate (LM), macroaggregate (MAC), microaggregate (MIC) and silt and clay (SC) fractions respectively. The diversity of the microbial community was analyzed via bacterial 16S rRNA gene and fungal internal transcribed spacer region (ITS) based PCR and subsequent terminal restriction fragment length polymorphism (T-RFLP). Additionally, bacterial community composition was analysed using next generation sequencing (NGS, Illumina Miseq). The T-RFLP data did show a significant effect of horizon depth on both bacterial and fungal community diversity ($P<0.05$). An effect of aggregate-size fraction was also seen, with the SC fraction supporting a significantly ($P<0.05$) distinct bacterial and fungal community compared with the larger aggregate-sized fractions (LM, MAC and MIC). There was no significant difference between the larger aggregate fractions in either case ($P>0.05$). Furthermore, NGS also showed the significant effect of both aggregate size and horizon on bacterial community structure at both the phylum and family level, with a significant interaction seen between the two parameters ($P<0.05$). These results indicate that both horizon depth and aggregate-size fraction support distinct microbial communities in grassland soils. Understanding these parameters is critical in our comprehension of terrestrial microbial ecology and its role in the sustainability of our agroecosystems.

How Teagasc advisory services can improve engagement with and empowerment of farm women

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In 2010, over 74,000 women were engaged in farming activities in Ireland, representing 27% of all workers. Of the 40,000 Teagasc clients, just over 3,500 are female owners and a further 1,300 clients are in partnership or under joint names. Similar to national figures, 11% of Teagasc clients are female in Co. Wexford.

This study aims to establish a profile of farm women in Co. Wexford and the extent of their engagement with advisory services; to identify their knowledge and learning needs; to investigate the barriers that prevent them from engaging with advisory services and to propose a strategy for improving the engagement of farm women and advisory services.

The research was carried out with women working and/or living on farms in Co. Wexford and included a questionnaire survey of 233 women. Focus group discussions were held with questionnaire respondents and key informants, and a case study was undertaken on a number of farm women who formed a group called 'Wexford Women Who Farm'. In addition, a survey of advisors was carried out to investigate the extent to which they currently engage with farm women and their attitudes towards the value of greater engagement.

The main barriers to engagement with advisory services were identified as: the feeling that women wouldn't be taken seriously (17.7%), that they aren't welcome (13.1%), a lack of self-confidence (12.6%), a lack of knowledge and training (10.5%) and isolation (10.3%). Women-only groups, more events and information, including family members in correspondence, and highlighting female farmers more in the media were the main suggestions offered to improve engagement. Approximately 70% of the women surveyed identified topics categorised into three areas; farm business management, technical skills, and other valuable knowledge and skills; that they would like to learn more about. The most popular topics from each area were: succession and inheritance (20%), personal development (20%), cash-flow planning (19%), soil fertility and applying fertiliser (18%), DAFM schemes (17%), and animal nutrition (16%). Training courses were identified by the women as their preferred way to learn (24%) and they also highlighted a preference to attend events after 6 p.m. on weekdays (21.9%).

The effect of antibiotics on vtx$_2$ bacteriophage transduction under bovine rumen fluid and broth conditions

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Verocytotoxigenic *E. coli* (VTEC) are a group of foodborne pathogens in humans, with cattle identified as the primary natural reservoir. The main VTEC virulence factors are the verocytotoxins (vtx) encoded on the genome of temperate bacteriophage. The expression of the *vtx* genes and toxin production have been linked to the bacteriophage lytic cycle, activated when the bacterial cell is exposed to DNA damaging agents such as antibiotics. The *vtx* genes can be transferred to other *E. coli* by transduction. This study investigated the effect of antibiotics, routinely used in cattle, on vtx bacteriophage transduction under bovine rumen fluid and broth conditions. Raw rumen fluid, irradiated rumen fluid and LB broth were inoculated with the vtx$_2$ donor (C600φ3538(Δvtx$_2$::cat)) and recipient (*E. coli* C600::kanamycin^R) strain under anaerobic conditions and incubated at 38°C. Samples were subjected to antibiotic treatment at two concentrations; the stress zone (minimal inhibitory concentration) (SZ) and the elimination zone (concentration used in cattle) (EZ) after three hours of incubation and analysed microbiologically at 6 time-points for 54 hours. The results showed a decline in bacterial numbers after antibiotic treatment at SZ concentrations in all three matrices but remained reasonably stable at EZ concentrations. Free vtx$_2$ bacteriophage (φ3538(Δvtx$_2$::cat)) was obtained in all matrices examined, as were high numbers of vtx2 transductants. This study suggested that exposure of VTEC in the rumen to antibiotics promotes vtx transduction and the emergence of new VTEC strains that are pathogenic to humans.

Effects of CO pretreatments and display temperature on the quality of vacuum packaged beef steaks

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In an effort to support consumer demand for quality meat products which provide an attractive colour and increased tenderness, value-added meat packaging technologies are required. Vacuum packaging is a common ageing technique used to increase tenderness and prolong shelf life, but the meat has an unattractive colour. Carbon monoxide (CO) causes meat to have a stable bright red colour which is desirable to consumers. Previous concerns have been raised that CO may be used to mask meat spoilage. This study investigated the effect of novel CO pretreatments applied to beef striploin steaks (*Longissimus thoracis et lumborum*, LTL) prior to vacuum packaging and display temperatures on colour stability, shelf life and tenderness. Steaks were exposed to a gas mixture of 5% CO, 60% CO_2 and 35% N_2 for 3, 5 & 7 h, followed by 28 days display at 2°C (good industry practice) or 6°C (mild abuse). Colour stability (a*, chroma values and *K/S* reflectance ratios), pH, purge loss, CO penetration depth, Warner Bratzler Shear Force (WBSF) and cooking loss were measured during storage. All exposure times induced the desirable colour with an exposure time of 5 h being optimum, as discolouration reached unacceptable levels (a* = 12, C* = 16) by the use-by date (28 days). *K/S* ratios could be more sensitive than colour parameters at monitoring discolouration as temperature had an effect on all *K/S* ratio values (P<0.05), while it had no effect on a* and chroma values (P>0.05). Temperature also increased purge loss (%) (*P*<0.001) and decreased pH (*P*<0.01), but did not affect WBSF, cooking loss and CO penetration depth (*P*>0.05). In summary, these results show that a CO-pretreatment of 5 h can enhance meat colour while allowing discolouration after 28 days display so as to not mask spoilage, thereby adding value to packaged meat.

Effect of α-lactalbumin concentration on the stability of infant milk formula under differing process conditions

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Heat treatment and homogenisation are process operations required during the manufacture of infant formulae and have a significant effect on product quality. This study investigated the interaction of these processes and the proteins used in infant formula, i.e., α-lactalbumin to β-lactoglobulin ratio. Three batches of model 1st stage infant formula containing 1.3% protein [12, 30 or 48% α-lactalbumin of total protein], 3.5% sunflower oil and 7.3% lactose were made at pilot scale (5 L batch; 30% solids). Batches were split; one half heated (Microthermics™) to 100°C x 30 s and homogenised at 175 bar 1st stage / 35 bar 2nd stage and the second half, homogenised and then heated (three replicate trials). Emulsion stability was analysed by laser light diffraction, viscosity, size exclusion chromatography and LumiFuge centrifugation. A significantly greater ($P < 0.05$) particle size distribution and concentrated viscosity (total solids 55%) was observed for emulsions containing 12% α-lactalbumin, heat treated post homogenisation compared to emulsions heat treated before homogenisation; increasing the α-lactalbumin concentration to 30 or 48% significantly reduced both the particle size distribution and viscosity upon concentration. A significant reduction in the amount of large and medium sized soluble aggregates was observed when the α-lactalbumin concentration in the emulsions was increased, with no significant difference observed between emulsions heat treated before or after homogenisation. The findings demonstrate the interactive effect of the process and protein type (i.e., α-lactalbumin to β-lactoglobulin ratio) on in-process and finished infant formula powder.

Sourcetracking microbial movement across the dairy chain

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In pasture-based systems, changes in dairy herd habitat due to seasonality results in the exposure of animals to different environmental niches. These niches contain distinct microbial communities that may be transferred to raw milk, with potentially important food quality and safety implications for milk producers. Here compositional metagenomics of a variety of microbial niches on the farm is employed to study the patterns of microbial movement through the dairy production chain and, in the process, investigate the impact of seasonal housing on the raw milk microbiota from the same herd over two sampling periods, i.e., indoor and outdoor. Beta diversity and network analyses showed that environmental and milk microbiotas separated depending on whether they were sourced from an indoor or outdoor environment. Within these respective habitats, similarities between the milk microbiota and that of teat swab samples and, to a lesser extent, faecal samples, were apparent. Indeed, SourceTracker identified the teat surface as the most significant source of contamination, with herd faeces being the next most prevalent source of contamination. In summary, sequence-based microbiota analysis identified possible sources of raw milk contamination, and highlighted the influence of environment and farm management practices on the raw milk microbiota.

The effect of different implementations of the 2003 Mid-Term Review of the CAP on technical efficiency of beef production. A comparative analysis

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The 2003 Mid-Term Review introduced decoupled payments as part of the Common Agricultural Policy; however it allowed the maintenance of limited coupled support. As a result, there are significant differences in subsidies granted in each Member State. We aim to explore the effects on technical efficiency of the different implementations in the beef sector in selected countries, as this was the sector where the highest level of coupled payments were implemented. Coupled support has been linked with deterioration of technical efficiency, while there is a lack of conclusive evidence regarding the effects of decoupled payments. This analysis intends to contribute to the literature exploring the effect of retaining different levels of coupled support, in addition to decoupled payments, on farm level economic performance. For this purpose, a country specific output distance function is estimated, together with the effects of a series of technical efficiency drivers, including subsidies. Unbalanced panel datasets for France, Ireland, Germany, Scotland and England and Wales are built using Farm Accountancy Data Network information for the years 2005 to 2012. Our estimates show that decoupled payments had a positive effect on efficiency in all countries, while the retention of coupled support had a significant negative impact on technical efficiency on French beef farms. This suggests that the maintenance of coupled support might compromise farm economic performance in the sector.

Feed substitution and economies of scale in Irish beef production systems

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Beef and dairy production are the most widespread farm activities in Ireland, with more than 90% of farms having a cattle enterprise. In 2010, 56% of Irish farms were classified as specialized beef farms, while over the period 2001-2013 the average share of beef production in total agricultural output value has been 28%. Despite its size and importance, the average profitability of the beef farming sector is relatively low, which raises concerns regarding the competitiveness and the long-term viability of many beef farms. Given the structural changes that have occurred in the Irish beef sector during the recent decades, increased market volatility and trade liberalization; the optimal structure of farms would be expected to vary over time and by production systems. This study aims to shed light on the evolution of the cost structures of Irish beef farms and those of specific production systems (*cow-calf*, *calf-to-finish*, and *other beef systems*). More specifically, a translog cost function has been estimated using a panel dataset of about 1,800 beef farms. The data are drawn from the Teagasc National Farm Survey and refer to beef enterprise level data from 2000 to 2011. Using the econometric estimates of the translog cost function, input demand elasticities, Morishima elasticities of substitution between purchased cattle, purchased feed, home-grown feed and veterinary services and economies of scale have been derived. Current results suggest that over the study period all inputs are substitutes for an average farm operating either in the *cow-calf*, *calf-to-finish*, or *other beef systems* (referring to store-to-finish and mixed beef output systems), whereas extensive economies of scale exist for the average *cow-calf* and *calf-to-finish* farm. The same trend is observed for the average farm in *other beef systems* until 2005, although post-decoupling the *other beef systems* farms are found to operate under decreasing returns to scale.

Achieving value chain governance and farm viability through co-operatives: international lessons for the Irish beef sector

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Irish beef farm enterprises are plagued by poor viability, compared to the dairy sector where the majority of enterprises are categorised as economically viable. A crucial differentiator is the presence of a well-developed infrastructure of processing and marketing co-operatives in the Irish dairy sector. Poor economic viability of beef farming has resulted in dependency on subsidy payments and off-farm employment. In 2016 the Department of Agriculture Food and the Marine (DAFM) legislated for the establishment of beef Producer Organisations (POs), facilitating producers to collectively strengthen their market positioning. With little or no experience of beef POs or comparable co-operative models in the Irish context, it is necessary to look internationally for insights as to how these POs can most effectively take form and operate structurally and organisationally. The research presented in this paper involved a review of POs in the European context and, in the absence of highly successful examples, an ethnographic case study of a US beef co-operative identified as a best-practice model internationally. Lessons for the new establishment of beef POs in Ireland from this international study are mapped onto the Irish institutional and sectoral context. Arrangements regarding production and supply of beef to and from the co-operative, and procedures for internal decision-making are elaborated, highlighting success factors and pitfalls. Important considerations for how beef POs may integrate to the value chain are identified. While responsiveness to value chain partners, such as retailers can support competitive advantage, POs should be vigilant in preventing dependency on partners and over-exposure to industry and market demands. Finally, evidence of how a co-operative approach can tangibly deliver various benefits to farm-level viability, sustainability and resilience is presented with lessons for what beef POs could potentially achieve for Irish farmers.

A diagnostic and control programme for Johne's disease on Irish dairy farms

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Johne's disease (JD) is an enteritis of ruminants with potential zoonotic implications. JD diagnosis and control present difficulties given JDs prolonged subclinical nature. In order to improve JD control in Ireland, PhD aims included conducting a national survey documenting high-risk husbandry practices employed on Irish farms, thereby targeting areas for improved management. As JD has been associated with on-farm economic losses internationally, this research programme aimed to analyse production losses associated with testing JD ELISA positive. Clinical cases of JD are rare in Ireland and studies of potential cross-protection by annual bovine tuberculosis (bTB) testing were also investigated. Finally, a longitudinal study was conducted to assess if successful JD control can be achieved using gold-standard management. Across all investigations, 312 farms were recruited, samples were collected from 4500 cows, and 10000 test results were generated (ELISA, PCR, faecal culture). However, no significant associations were identified between JD ELISA positivity and production parameters, an important consideration in promoting on-farm JD control for Irish farms engaged in high-risk management practices facilitating JD transmission. Annual bTB testing was associated with an increased prevalence of JD ELISA positive results and indicates that sampling for the purposes of JD surveillance should be avoided for 71 days post-TB test administration. Coupled to increased antibody responses, interferon-γ production was also significantly increased post-bTB testing. As cell-mediated immunity is particularly important in the control of JD systemically, bTB testing may be contributing to the low levels of clinical JD in Ireland and warrants further investigation. Finally, on-farm sero-prevalence was decreased by implementation of gold standard protocols. Eradication was not achieved, however, highlighting the long-term commitment required for effective JD control. This research programme has greatly contributed to the work of Animal Health Ireland's JD technical working group and immensely improves understanding of practical measures necessary to control JD.

Low cost, multi-purpose genotyping panels for dairy and beef cattle

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The selection of animals based on DNA has revolutionised animal breeding but the high cost associated with obtaining the genotype has limited its widespread uptake. The objective of the thesis was to 1) develop a low-cost, low-density, multi-purpose genotyping panel for the procurement of reliable genotype information, and 2) quantify the long-term consequences of using such low-density genotype panels in breeding programs. The in-silico development of genotype panels was based on genotypes from up to 58,705 beef cattle. Results indicate a minimum of 300 single nucleotide polymorphisms (SNPs; DNA variants) were required to accurately predict breed composition with a mean standard error of 0.036. Alternative novel strategies were used to identify informative SNPs with the purpose of developing a low density genotype panel which, once imputed to higher density, could be used in genomic evaluations. A minimum of 3,000 carefully selected SNP were required if selected using the genomic architecture of the breed from which they would eventually be used; a minimum of 6,000 SNPs would be required if the panel was to be informative across breeds. The long-term repercussions of using low density panels were evaluated using simulations. Successive imputation across generations, using approaches currently adopted globally, was suboptimal with an accumulation of errors over generations; an approach based on stepwise generational imputation was recommended to reduce the erosion in accuracy of imputed genotypes over generations. The advent of genomic evaluations has reduced generation intervals intensifying the importance of screening for DNA variants contributing to congenital defects. Using high density genotype data from 44 phenotypically normal calves and 23 half-sib contemporaries with a missing cleft pallet phenotype, a region on chromosome 13 was identified to harbour the underlying mutation. Appropriately designed genotype panels, coupled with optimised imputations strategies, can facilitate the widespread adoption of low-cost genome-based breeding programs.

Effect of housing conditions on performance and welfare of finishing beef cattle

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Space allowance and floor type are identified as critical factors affecting the performance and welfare of finishing cattle indoors. In Ireland, concrete slatted floors are the predominant cattle housing system and the current space allowance on concrete slats is 2.5m^2 for a 500 kg animal. At EU level, there are calls to increase space allowance for beef cattle and to replace concrete slats with an alternative flooring type. Experiments were designed to evaluate the performance and welfare of finishing: i) bulls accommodated on concrete slats with or without rubber mats and ii) heifers accommodated on concrete slats with space allowances of 3.0, 4.5 and 6.0 m^2 per head and straw at 6.0 m^2 per head. Experiment 1 demonstrated that replacing concrete slats with rubber mats improved the average daily gain (1.41 *vs.* 1.24, s.e.m. 0.04) (*P*<0.01) of bulls but had no effect (*P*>0.05) on carcass weight. Dirt scores were not affected (*P*>0.05) by floor type. The number of hoof lesions acquired during the experiment was greater (*P*<0.01) on rubber mats (16 *vs.* 11, s.e.m. 0.9). Experiment 2 showed no difference in carcass weight between heifers at the different space allowances or on the straw treatment despite average daily gain being greater (*P*<0.05) on straw (1.34 *vs.* 1.19, s.e.m. 0.03). Heifers housed on straw had longer lying times (*P*<0.001) and greater dirt scores (*P*<0.001) by the day of slaughter compared to those on slats. It is concluded that; provision of a more generous space allowance to finishing cattle on concrete slats is not warranted on the basis of carcass weight or dirt scores; rubber mats and straw as underfoot conditions did not enhance animal performance or welfare. These findings will be used to inform policy at national and EU level on space allowance and floor type recommendations for finishing beef cattle.

POSTER ABSTRACTS

POSTER ABSTRACTS

An examination of the biochemical control of feed efficiency in beef cattle

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A range of physiological processes across multiple tissues has been hypothesised to contribute to variation between individual cattle for feed efficiency. The objective of this project was to examine (i) mitochondrial abundance and functionality of respiratory chain complexes (CI-IV) in muscle tissue and (ii) differential gene expression in adipose tissue of pure bred Simmental bulls and heifers, divergent for feed efficiency. Individual dry matter intake (DMI) and ADG were measured in heifers (n=24) and bulls (n=28) with an initial live weight of 367kg± (SD=42.4) and 381kg± (SD=51.5), respectively. RFI was calculated and animals were ranked by RFI into high (HRFI; inefficient), medium and low (LRFI;efficient) groups. This resulted in 8,8,9,9 high and low RFI heifers and bulls, respectively, selected for further study. Overall ADG and daily DMI for animals was 1.5kg (SD= 0.13) and 9.25kg (SD=0.2), respectively. High RFI animals consumed 10% more (P<0.05) than low RFI animals. Liver and muscle biopsies were harvested at the end of the feed intake recording period and spectrophotometric assays performed. Adipose tissue was collected at slaughter and qPCR was performed. At the mitochondrial level, we observed that there was no effect of RFI status or gender on mitochondrial abundance in either muscle or liver tissue. There was evidence of an RFI x gender interaction (P < 0.05) for CX1 in muscle tissue. Higher activity of CXIV in liver tissue was observed for HRFI animals (P<0.05). Higher (P<0.05) transcript abundance for ACLY and lower (P<0.05) abundance for ACAT1 and HMGCS was evident for adipose tissue of HRFI compared with LRFI animals. Increased ACLY expression is consistent with the higher fat deposition of HRFI animals. The increase in ACAT1 and HMGCS in LRFI animals may be explained by the lower DMI of these animals. LRFI animals synthesise less dietary derived nutrients and may need to compensate for this at the molecular level. Our work highlights that biological processes in multiple tissues may be contributing to RFI in beef cattle.

Effect of winter growth rate on subsequent performance of suckler bulls and ultimate muscle colour and sensory quality of beef

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Variations in early life growth rate can influence the physiological state of beef cattle and muscle characteristics, which in turn influence meat quality. The effect of restricting growth during winter on the performance during subsequent growing and finishing periods, and muscle colour and sensory characteristics of beef from bulls, was investigated. Weaned Charolais and Limousin sired suckler bulls (n = 42) were assigned to one of three target winter growth rate treatments: 0.6, 1.0 and 1.5 kg liveweight/day. The feeding regimes to achieve the target growth rates were 2, 4 and 6 kg concentrate daily, respectively, plus grass silage *ad libitum.* The duration of the winter feeding period was 123 d after which bulls were turned out to pasture and grazed for 99 d before re-housing and finishing on *ad libitum* concentrates plus grass silage. The duration of the concentrate finishing periods was 71, 65 and 51 d for 0.6, 1.0 and 1.5 treatments, respectively. Liveweight gain during the grazing period was higher ($P < 0.001$) for the 0.6 treatment than for the 1.0 and 1.5 treatments, which did not differ. Muscle colour, metabolic enzyme activity and fibre type distribution were similar ($P > 0.05$) between treatments. Apart from tenderness, which was rated higher ($P < 0.05$) for the 0.6 compared to the 1.0 treatment, juiciness, beefy flavour, flavour liking and overall liking scores of the beef were not influenced by winter growth rate. Overall, restricting growth rate during winter had little effect on the animal performance during subsequent periods or on beef quality.

The use of faecal NIRS to assess diet effects on digestive processes in steers

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Faecal near infrared spectroscopy (faecal NIRS) is a rapid technique used to assess chemical composition of faeces, with chemical differences in faeces showing differences in digestion processes between animals. The aim of this study was to assess the use of faecal NIRS as a rapid technique to assess chemical differences of faeces of cattle offered diets with a series of additives designed to alter methane emissions. Faecal samples were collected from 72 steers at the end of a 56 day period of measuring feed efficiency, expressed as residual feed intake (RFI). Diets were: Control (TMR based diet, n=18), and 3 diets in which rapeseed meal was replaced with Nitrate (18 g nitrate/kg DM in the form of calcium nitrate, n=19), Oil (increased by 12g/kg DM by use of maize dark grains, n=19), Nitrate/Oil (a combination of Nitrate and Oil, n=16). Faecal samples were dried and milled before being scanned in duplicate at 2 nm intervals between 1100 and 2500 nm. Averaged spectra were transformed using SNV and Detrend, before being assessed using PCA, using all samples and subsequently individual samples based on diet. Separation of diet in to three clusters was observed in the PCA plot containing all diets (1; Control and Oil, 2; Nitrate, 3: Nitrate/Oil). Diet had a significant effect on PC-1 (P=0.007) but not for PC-3 (P=0.092), with wavelengths associated with protein, lipids and cellulose/sugars showing highest loadings. PCA plots for individual diets showed no separation by RFI level. This study shows the potential for NIRS as a rapid technique to assess chemical differences of faeces associated with differences in digestion processes, with the presence or absence of Nitrate having a large effect.

Novel recombinant protein vaccine for enzootic abortion of ewes (EAE)

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Chlamydia abortus, the causative agent of EAE, gives rise to placentitis and late term abortions. The disease is estimated to cost approximately €5 million annually in Ireland. Reports of sporadic cases of abortion associated with the modified live commercial vaccine suggest a need for a safer vaccine. A recombinant protein vaccine that offers similar levels of protection to the commercial vaccine may provide the solution. The aim of this study was to evaluate the ovine immune response to two recombinant proteins from *C. abortus* [the macrophage infectivity potentiator (MIP) and the chlamydia protease activity factor (CPAF)] and to determine their ability to protect ewes against EAE. Fifty *C. abortus* sero-negative ewes were randomly allocated to one of 5 treatment groups. The groups received (1) 100 µg of MIP (2) 100 µg CPAF (3) 50 µg MIP and 50 µg CPAF combination (4) phosphate buffered saline or (5) Enzovax (MSD Animal Health) 6 months prior to tupping. The animals were subsequently challenged subcutaneously on day 90 of gestation (1×10^6 IFUs of C. abortus C95/27). Enzovax was highly effective with a 100% efficacy at preventing abortion while the MIP/CPAF combined vaccine offered the best protection of the novel vaccines with a 50% efficacy rate. Ewes receiving MIP/CPAF compared to the PBS control group had lambs with significantly higher birth weights ($P < 0.05$) while their gestation length approached being significantly longer ($P = 0.06$). We also found that the combined MIP/CPAF vaccine gave rise to a lower and delayed anti-chlamydia antibody response post challenge, similar to the commercial vaccine. It is suggested from this study that a combined protein vaccine is more effective than a single protein vaccine. Further work with these proteins and others in this bacterium's repertoire could produce a safer and effective vaccine to combat EAE.

Designing a full farm system bio-economic model for the Irish sheep industry

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Bio-economic modelling involves the integration of economic models with biological processes that can be used to assess technical, biological and economic changes to a farm system. The accuracy of model outputs is dependent on the availability of accurate input data to parameterise the model. A detailed literature review revealed that there was a paucity of data relating to Irish sheep farm parameters. Therefore a detailed survey was undertaken to assess the current management practices on Irish sheep farms. With the aid of data from the detailed survey undertaken, as well as from previous Irish and international sheep research, the Teagasc Lamb Production Model (TLPM), a stochastic simulation model was developed to investigate the effects of system changes on farm profitability. The TLPM was validated against data from 20 Irish commercial sheep farms using data sourced from the Teagasc e-profit monitor. To demonstrate potential applications of the model, a number of scenarios were investigated including the effect of lambing date (mid-season vs. early lambing flock) on farm profitability. Results demonstrated that early lambing flocks were less profitable than mid-season lambing flocks due to increased variable costs, most notably feed costs. The TLPM was also used to evaluate the effect of stocking rate and ewe prolificacy on profitability; results demonstrated that the number of lambs weaned per hectare along with the amount of grass grown and utilised are the key driver of profitability; however, increasing the number of lambs weaned per hectare without increasing grass growth and utilisation is counterproductive. Another key use of the TLPM is in the development of economic values for the national sheep breeding objectives, which will allow for more accurate identification of genetically superior animals. The development of the TLPM provides the Irish sheep industry with a platform for investigating key factors affecting farm profitability.

Genetics of longitudinal growth and feed efficiency data

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The accurate assessment of an animal's growth and feed efficiency pattern is reliant on the availability of multiple live weight and feed intake records; however in most livestock species such longitudinal data can be available sporadically and at a limited number of time points across an animal lifetime. Growth and feed efficiency measures can be mathematically modelled at a phenotypic or genetic level using growth functions or random regression models. The objective of this thesis was to evaluate alternative growth functions and their ability to model and predict phenotypic longitudinal data, and consequently estimate genetic (co)variance components pertaining to live-weight and feed efficiency across an animal's life. Pig live-weight and feed intake records were available from a Finnish pig breeding company (Figen Oy) on 10,201 pigs; live-weight and feed intake records were recorded for all animals. A Gompertz mixed model achieved the greatest accuracy when predicting future live weight records. In addition moderate to strong heritabilities were estimated for each of growth function parameters, asymptotic mature weight (0.10 to 0.40), the logarithmic ratio of mature weight to birth weight (0.32 to 0.69) and rate of maturation (0.13 to 0.45), indicating that ample genetic variation for the selection of the growth function parameters in the Gompertz growth function. Random regression Legendre polynomial models were fitted to the live weight and feed efficiency data as they have a superior ability to model the trajectory of longitudinal data with less bias compared to multi-trait models and allow for the prediction of estimated breeding values across each day of an animal's life. Moderate to strong heritability's estimated for live weight and feed efficiency measures across an animal's lifetime. Results from this thesis illustrate the potential to increase the rate of genetic gain in growth and feed efficiency traits through the exploitation of growth functions; these results also allow for the refinement of national genetic evaluations for growth and feed efficiency traits.

International genetic and genomic evaluations for carcass traits in beef cattle

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The main revenue source for beef farmers is carcass value (carcass weight, conformation and fat score), which is influenced by genetic and non-genetic factors. In order to improve the profitability of the herd, accurate means of evaluating both genetic and environmental factors influencing performance are necessary. The global exchange of genetic material has increased interest in the ability to compare breed stock from different countries. The objectives of this project were to generate tools for the enhancement of carcass trait evaluations both at a national and international level. Using carcass data from the Irish commercial population sire genetic profiles were generated for carcass traits across age at slaughter using random regression models. Heritability estimates for carcass weight, conformation and fat score across age at slaughter varied from 0.44 to 0.53, 0.40 to 0.45 and 0.24 to 0.31, respectively. Genetic correlations within each trait weakened with increasing interval between ages, suggesting a different genetic background for carcass traits across different ages. These genetic parameters indicate that genetic variability in growth rate at different ages exists, which can be exploited through breeding programs and used in decision support tools. Using random regression models, a second study on UK carcass data quantified the contribution of herd environment to carcass characteristics by generating finishing herd specific profiles for carcass traits across ages at slaughter. Across age at slaughter, the finishing herd accounted for between 31% and 72%, 22% and 56%, and 11% and 44% of the phenotypic variance in carcass weight, conformation and fat score, respectively. The finishing herd environment is therefore an important contributor to carcass trait variability and amenable to improvement with management practices. The genetic connectedness between the two countries will be investigated and an across country evaluation carried out, leading to more accurate rankings and selection of foreign bulls between each county.

Evaluating ewe prolificacy and stocking rate effects on flock performance and pasture production

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Grazed grass is the most economic source of nutrition available to ruminants in temperate grazing regions and has the potential to supply up to 95% of the energy requirements of sheep. Ewe prolificacy potential (PP; predicted number of lambs born/ewe/year) and stocking rate (SR; ewes/ha) are two key drivers of output in grass-based lamb production systems. This study focused on the effect of ewe PP and SR on animal performance and pasture production and utilisation in a grass-based lamb production system. The study was conducted over three years at the Teagasc, Sheep Research Demonstration Farm, Athenry, Co, Galway. The study had a 2 x 3 factorial design, consisting of two PP and three SR levels incorporating 360 ewes (180 medium prolificacy potential (MP – Suffolk X ewes) and 180 high prolificacy potential (HP – Belclare X ewes). Stocking rates were low (LSR; 10 ewes/ha), medium (MSR; 12 ewes/ha), and high (HSR: 14 ewes/ha). Ewes were lambed in early March each year and grazed predominantly perennial ryegrass swards in a 5-paddock rotational grazing system. Increasing ewe PP increased carcass output per hectare without any negative effect on lifetime lamb performance or herbage utilisation per hectare. As SR increased, carcass output per hectare increased despite reductions in lamb average daily gain, with the quantity of grass utilised per hectare highest at the HSR. Sward quality was not influenced by ewe PP or SR, however, the proportion of leaf from ground level in sward was 5% higher in the MSR and HSR systems compared to LSR system. The results from this thesis provide evidence that increasing output from a grass-based lamb production system is achievable through increasing ewe PP and SR.

Effects of production system and finishing strategy on male dairy calves

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The recent abolition of milk quota and subsequent expansion of dairy cow numbers increased the proportion of male dairy calves available for beef production. Although 20% of these calves are exported to continental Europe each year, these animals account for 30% of the national steer kill. The majority of dairy steers are slaughtered at 26 to 30 months of age, thus potential exists to increase efficiency and output of male dairy calf-to-beef production systems. The objectives of this study were to establish male dairy calf-to-beef production systems that have the potential to slaughter animals at a younger age, maximise profitability and reduce greenhouse gas (GHG) emissions. Animals were managed in high concentrate and pasture-based systems. Bulls were slaughtered at 15 and 19 months of age, while steers were slaughtered at 21 and 24 month of age. Animal measurements included live weight and average daily gain, ultrasonic muscle and fat depths, animal and carcass measurements, animal behaviour and carcass performance. Herbage offered and group concentrate intakes were also recorded. The Grange Dairy Beef Systems Model and BEEF Greenhouse gas Emissions Model simulated economic implications and GHG emissions, respectively, for the production systems using biological data generated from this study. Results showed that carcass weights and fat scores were greatest for bulls and steers finished indoors at 19 and 24 months of age, respectively. While slaughtering bulls at 15 months of age reduced GHG emissions, the reliance on concentrate input made the profitability of this system questionable for producers. Finishing steers during the second winter produced the greatest GHG emissions and the increased feed costs associated with winter finishing returned a modest profit, relative to the alternative production systems examined. Finishing bulls and steers at pasture, supplemented with concentrates, during the second season proved the most profitable systems with lower GHG emissions.

Genetic selection for improved milk quality in Irish dairy cattle

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The aim of this study was to predict the protein and free amino acid (FAA) composition and colour of bovine milk using mid-infrared spectroscopy (MIRS), the method of choice worldwide for routine bulk tank and individual animal milk recording, and to determine phenotypic and genetic factors associated with these traits. Models were developed to predict individual protein fractions (alpha-S1, alpha-S2, beta, and kappa-casein, alpha-lactalbumin, beta-lactoglobulin-A and beta-lactoglobulin-B), FAA (glutamic acid, glycine, lysine, arginine, aspartic acid, serine and valine) and milk colour directly from the MIR spectrum. Up to 557, 715 and 601 individual milk samples with reference values for proteins, FAA and milk colour, respectively, were available for equation calibration. An additional 171,279 (10,162 cows) records with MIRS data were available from the years 2013 to 2015, inclusive. The mahalanobis distance was calculated for each milk sample to detect spectra which deviated greatly from the samples used in calibration. Factors associated with each of the milk quality traits were quantified using linear mixed models. Correlations between true and predicted values of individual proteins, FAA and milk colour were up to 0.76 (total whey), 0.75 (Glycine), and 0.74 (yellowness), respectively. Stage of lactation, parity, calendar months of the year, milking time and breed were associated with protein factions and FAA. Trends in milk protein fractions and FAA across month of the year suggest that the quality of milk for different products varies across the year; this information could be useful as a decision support tool for processors. All proteins and FAA exhibited genetic variation and traits were low (h^2=0.10; alpha-S1-casein) to moderately heritable (h^2=0.64; valine). Findings from this study indicate that prediction of protein fractions; FAA and milk colour by MIRS could benefit the dairy breeding industry worldwide through genetic selection of animals with higher quality milk.

Automating the milking process in a pasture-based system

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The first automatic milking system (AMS) was commercialised in the Netherlands in 1992, and the concept has since increased in popularity globally. However, the greater proportion of machines in place are associated with indoor systems. The objective of this thesis was to determine the feasibility of an AMS within an Irish pasture-based system. This study examined the effect of different supplementation strategies and animal genotypes on cow traffic and the environmental, social and economic sustainability of such a pasture-based system. Feeding additional concentrates had no significant effect on cow traffic parameters in early lactation; however, supplemented cows did return to the milking yard more quickly in late lactation. There were also significant differences between breeds, with Norwegian Red cows moving through the system more efficiently, compared to Holstein Friesian and Jersey crossbred cows. They had a significantly shorter return time from pasture and waiting time in the pre-milking yard than the other breeds. Environmental and social sustainability were evaluated on seven and ten commercial farms operating with AMS and conventional milking system (CMS), respectively. Farms with AMS used 50% more electricity than CM farms. Labour usage was recorded for three consecutive days each month. Milking with AMS resulted in a 36% reduction in labour requirement compared to a CMS, despite an additional time requirement for grass allocation with AMS. The profitability of AMS was compared with that of CMS with medium (MS) and high specification (HS) milking parlours. Profitability of AMS was lower than a CMS of MS, while the AM system had similar profits to a CMS of HS. This thesis showed that innovative methods of pasture management allow the integration of AMS and grazing in an Irish pasture-based system and it provides insight into the factors which affect the efficiency and sustainability of such an integrated system.

Environmental impact of mole and gravel mole drainage on grassland based dairy production systems

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Shallow drainage techniques are strategies which can be used on Irish farms to increase grass utilization where soils have impeded drainage. This is particularly pertinent in the context of projected increases in milk production (>20% nationally) where these soils will be required to carry higher stockings rates. There is however a lack of research on the effect that these drainage techniques may have on greenhouse gas (GHG) emissions and nutrient losses to water which are important in terms of our commitments on climate change and the Water Framework Directive. Hence we set up a series of experiments at Solohead Research Farm (52°30'N, 08°12'W) in order to investigate the impact of mole drainage on soil greenhouse (GHG) emissions and nutrient losses to water. This involved measurement of soil nitrous oxide (an important GHG with 300 times the global warming potential of carbon dioxide), methane and carbon dioxide emissions, changes in soil carbon storage (0-60 cm depth) and the measurement of nitrate-N and phosphorus (P) losses to water in surface and subsurface runoff, and to groundwater. As expected, the drained grasslands had a lower watertable depth and decreased soil moisture content compared to undrained grassland. Despite this change, there was no difference in soil GHG emissions or soil carbon storage between drained and undrained grassland. In terms of water quality, drainage treatment lowered the P losses by enhancing infiltration and retention due to soil chemistry. Drainage treatment increased the overall nitrate-N losses to water, however mean nitrate-N losses were below the 11.3 mg L-1 threshold for drinking water. Hence we conclude that shallow drainage techniques can be implemented on farms under similar management to the present study with no impact on soil GHG emissions, lower P losses and with a minor impact on Nitrate-N losses to water.

Weed control in willow crops

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Willow is a crop that has excellent potential as a source of biomass for renewable energy. Weed competition in the crop is one area that can hinder good yields and consequently good returns on investment. Minimal work has been conducted on weed control measures in willow crops. Experiments on different weed control measures were used over three growing seasons. Treatments involved applications of complete weed control, no weed control, interrow cultivation, rotavation and interrow herbicide spraying by one and two applications along with plastic mulch applications, use of a broadcast herbicide and use of a cover crop in one year. A complete randomised block design was used in 2013 and 2014 while a complete split plot design was used in 2015 incorporating high and low weed pressures. Results from the three years experiments showed on average that excellent weed control through hand weeding resulted in a nearly 50% increase over no weed control at all after one growing season. Interrow treatments resulted in an average of 27% yield increase over no weed control. Weed control treatments were only applied during the first growing season; the experiments were then coppiced and left to grow for two years. The trials planted in 2013 were then harvested and measured in 2015/2016 at the first commercial harvest. Yield benefits observed after one year were still evident at this harvest with complete weed control yielding 88% higher and interrow treatments yielding 53% higher than no weed control. To conclude, efficient weed control can substantially improve growth of willow crops during their first growing season. Interrow weed control treatments offer an effective weed control approach.

Novel propagation system for Miscanthus x giganteus

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Miscanthus is a sterile triploid hybrid which is vegetatively propagated from rhizome pieces. The high cost of rhizome material at €1,900ha has deterred many potential growers. Sugarcane propagation technology was applied to miscanthus, whereby the stem rather than the rhizome was used as the vegetative material. Preliminary plant material costs for stem-based propagation techniques are €140ha. Hand planted field experiments were conducted spring 2014 on two sites to examine propagation from stem material harvested in October 2013 and cold stored over winter. The experiments showed very little germination (5%), but partial emergence in some plots identified that the system could work under Irish conditions. Planting depth was the only variable throughout the experiment. A prototype planting machine suitable for commercial up-scaling of a stem propagation system the " InSteminator" was designed and successfully used to sow plots in a time of sowing experiment in autumn 2014 and spring 2015. This experiment was used to investigate whether stem pieces could be harvested and planted in the ground to eliminate the expense of cold storage. Greatest establishment was observed from plant material harvested in September and sown in September. Emergence dates, plant counts and plant heights were recorded throughout the growing season as well as a destructive biomass harvest. The highest yielding treatment was September stem harvest and September planting, producing 224% more biomass (kg DM/ha) than the next best treatment (October harvested and October sown) at Knockbeg, Co. Laois and 615% more biomass than the October treatment in Oak-Park, Co. Carlow. Spring sown treatments of stems harvested in September and stored at 2°C, - 2°C and stems harvested in spring were shown to have negligible establishment. Miscanthus can be successfully propagated from stem cuttings under Irish conditions.

Soil greenhouse gas emissions in oilseed rape cropping systems as affected by alternative cultivation techniques

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To achieve sustainable oilseed rape (OSR) production in Ireland, management strategies must be utilised to optimise nutrient uptake and seed yield whilst minimizing greenhouse gas (GHG) emissions, especially nitrous oxide. This study analysed rates of soil respiration (CO_2) plus nitrous oxide (N_2O) and methane fluxes (CH_4) across a range of soil cultivation and crop establishment systems in contrast with other management factors. These included conventional (Moldboard Plough) and non-inversion (Minimum and Strip Tillage) cultivation in combination with applied nitrogen rates, timings and the use of growth regulators. The impact of plant row spacing and seed rate on conventional and low-biomass varieties was also evaluated. The results of this study indicate soil respiration (CO_2) was the largest contributor to greenhouse gas emission followed by N_2O, whereas CH_4 fluxes had little impact on overall GHG emissions. N_2O emissions were strongly influenced by the relative water-filled pore space and rainfall coupled with elevated soil NH_4^+ and NO_3^- concentrations. N_2O emission factors for OSR systems ranged between 0.12 – 1.7% but on average were found to be lower than the IPCC 1% default value. Strip-tillage intensified pulse N_2O emissions at higher fertiliser rates and similar soil moisture contents compared to conventional tillage. Slight differences in GHG emissions were observed between the two cultivars at conventional seed rates and at wider row spacing's. Growth regulator increased N_2O emissions and generally reduced soil respiration rates, though the effects on both gases were modest. Management can mitigate nitrous oxide emissions through efficient N timing and application measures, with the potential to reduce GHG emissions and meet future target requirements. In contrast there is less scope to control or reduce CO_2 emissions through tillage management, as it's strongly dependent on seasonal factors such as temperature, soil moisture and crop phenology.

Effect of row spacing and seed rate on the growth and development of Winter oilseed rape

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Winter oilseed rape (*Brassica napus*) is the most widely grown oilseed crop in northern Europe. Oilseed rape is typically sown at 125mm row spacing at seed rates of 50-80 seeds m^{-2}. Recent interest in low soil disturbance strip-tillage for establishing oilseed rape has resulted in commercial growers seeding at 600mm row widths with relatively little research available to support this practice. Experimental field trials to determine the impact of row width (125, 250, 500 or 750mm), seed rate (10, 15, 30 or 60 seeds m^{-2} respectively) and variety biomass type (standard and semi-dwarf) on crop establishment, growth and yield were carried out over two growing seasons. These treatments were established in conventionally cultivated plots in a factorial arrangement with four replications. Crop establishment was determined post emergence, while biomass, leaf area, total green area and crop light interception were measured at regular intervals during the season. The components of the crop at harvest were analysed and final yield values determined. When sown at a wider (750mm) row width, poorer establishment was recorded at higher seed rates compared to narrower row spacings. The wider row spacing's also limited leaf area production with a 31% reduction in green area index compared to 125mm row spacing at 60 seeds m^{-2}. However, the differences in emergence and overall biomass development were not carried through to yield at harvest, as there was no significant difference between the treatments (P=0.651). There was no significant effect of row width and variety type on yield (P=0.263). This suggests that there is a limit to the impact of increasing canopy size on oilseed rape yield, allowing it to achieve a stable yield in a wide number of sowing combinations.

Using genomic selection to increase the rate of genetic gain in perennial ryegrass breeding

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Perennial ryegrass (PRG) is the most important forage species in Ireland and a key element in the low cost pastoral production system promoted by Teagasc. Teagasc runs the national breeding programme that aims to deliver improved PRG varieties to farmers that increase profitability by exhibiting high performance in key indices of the Pasture Profit Index. Improved varieties are currently developed using phenotypic recurrent selection and are aimed at improving traits such as seasonally distributed yield and disease resistance. However, genetic gains for yield have been modest. There are many reasons for this, including the time it takes to complete one cycle of selection, which can be as long as a decade. However, it may be possible to complement traditional phenotypic selection with genomic information to increase both selection intensity and the number of cycles of selection per decade, resulting in increase in the rate of genetic gain. Genomic selection may also offer the ability to breed for traits, such as digestibility, which are difficult to select for, but important in increasing the metabolisable energy available per unit intake to the grazing animal. We have developed a training population in perennial ryegrass to evaluate the potential of using information in the genome to predict breeding value, measured as predictive ability and relative efficiency to phenotypic selection. Using the traits heading date (high heritability) and crown rust (medium heritability), we have been able to demonstrate high predictive ability when using genome information produced using next generation-sequencing based genotyping approaches to predict phenotypes, and our attention is now turning to predicting yield and pasture quality.

Fertiliser use efficiency in grassland: interaction of lime and phosphorus fertiliser

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Adequate soil phosphorus (P) supply is required to meet the demands of high yielding grassland and grazing animal production systems. Current advice does not account for differences in soil P dynamics and potentially different P supply to grass as affected by soil type and soil pH level. The objectives of this project were to investigate the relationships between soil pH and P fertiliser with soil P availability, grass yield and grass P concentration across different soil fertility gradients. The overall aim of this project was to develop new soil specific P fertiliser and lime advice to underpin future grassland recommendations.

To achieve these objectives, a series of studies at various scales i.e. laboratory incubations, soil-plant microcosm, field plots and on-farm field trials in four regions, were established. These experiments allowed for an in-depth investigation of soil P, herbage P concentration and fertiliser P response on some of the most commonly farmed soil types in Ireland.

Results from the microcosm studies indicate a wide range in grass dry matter yield potential across 22 soil types under chemical and organic P applications with and without lime applications. At field plot scale, the importance of soil pH correction prior to P application was shown for maximizing P fertiliser use efficiency. Results show that regardless of P application rate soil pH has an overriding effect on soil P availability. At a farm scale annual soil nutrient balance (e.g. P inputs – P offtakes) can have more long term effects on soil fertility and grass yield and quality as soil P reserves respond more slowly to fertiliser management, as either drawdown or build-up, over time. These results demonstrate the requirement for soil specific P recommendations in order to maximize the efficiency of expensive P fertilisers on farms and protect finite rock P reserves.

Taping into phosphorus reserves in Irish grassland soils

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Phosphorus (P) is a finite resource but an essential nutrient for global food production. P demand has been increasing over the years driven by a growing requirement for global food supply and economic targets in the agro-food sector. Due to increasing costs and intensification of P use in the non-food sector, there is now a downward trend across Europe in the application of P as fertilizer. Optimising soil P efficiency is becoming essential for farmers and soil P reserves are being targeted as complementary source of P. As part of a national study to assess soil quality in Ireland, P resources were evaluated in 31 grassland sites under intensive and extensive management regimes. Labile and fixed P pools were characterized following P sequential fractionation procedure (Hedley *et al.* 1982), extracting P from soil according with its speciation and availability. Results, from the first 16 grassland sites analysed so far, show that labile P represents 7.6% of the total P in the soil, covering 4.2% of inorganic and 3.4% of organic P. Hedley's fractions (NaOH-P, NaOHsn-P, HCl-P and residual P) described as unavailable P fractions for plant uptake, represent about 90% of the soil total P. Proportions of inorganic and organic P (27.6% and 30.9%, respectively) show that organic P pool greatly contributes to the total soil P. Evaluation of P fractions indicate that Irish grassland soil contain significant amounts of unavailable P however current plant P uptake rates suggest that part of these P reserves are not been used for plant production. Soil P reserves may hold the potential to become plant available, minimizing P fertilizers inputs and ultimately reducing costs with soil fertilization and improving soil P efficiency. To use P reserves as a complementary source of P further research targeting organic P turnover will be assessed.

Stability of Sitka spruce in relation to thinning type, intensity and timing

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Windthrow, i.e. the overturning of trees, is common worldwide, especially in areas that experience winter storms. Ireland is one such area, where windthrow is a continuous cause of economic loss in forestry plantations. This project seeks to determine how thinning by differing intensity and timing can affect the stability of Sitka spruce stands. Tree pulling tests were conducted on a surface water gley forest in Frenchpark, Co. Roscommon, where five different thinning treatments were replicated three times. The thinning treatments differed according to the basal area removed (light, medium, heavy, no thin and a medium thin performed three years delay). Four trees representing the average tree in each plot were tested until failure of the roots to calculate the trees' maximum overturning moments. Results indicate that trees from thinned plots have greater overturning moments than trees in unthinned plots, with the heavy thinned trees being the most stable. Additionally, heavy thinned trees had the largest root plates and crowns as a result of the new environmental conditions created by thinning. A positive relationship between the root and the crown spread was found. Further, the depth of the root plate was found to be influenced by the water table depth at the beginning of the growing season in the plot and not by the thinning treatment applied. The results of the tested trees in the delayed thinning suggest that timing of thinning is a determinant factor in crop stability, as trees react quicker when they are released in early stages.

Does alley width affect growth of wild cherry timber trees when grown in alleys of willow coppice?

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Alley coppice is a new form of agroforestry in which a biomass crop is grown in combination with high value timber trees which are planted in alleys. This land management system produces: carbon neutral sources of energy in 2-3yr rotations, valuable timber trees for long-term carbon fixation and many environmental services. Both wood components contribute to securing future energy supplies and mitigating climate change. By establishing the first alley coppice trials in N. Ireland at AFBI Loughgall (May 2013), we investigated the interactions of the system components: 5 clones of willow for biomass in combination with wild cherry as valuable timber trees (6 clones) and alley widths of 2m and 4m. The trial design was in 3 randomised blocks with a split-split-split plot treatment structure. The alley width treatments of 2m and 4m was applied to 2 main plots within each block; each main plot was split to form 6 sub-plots which the 6 cherry clones were planted. Each subplot was further split to form 5 sub-sub plots in which the 5 willow clones were planted. The total height and root collar diameter of cherry trees were recorded monthly in 2014 and 2015. Data was analysed by analysis of variance appropriate to this treatment design. At the sub plot level there were very highly significant (P<0.001) main effects among all cherry clones in each year for mean total height and mean root collar diameter. At the main plot level, an alley width of 4m gave a significantly higher mean total height of cherry trees (P<0.05) compared to a 2m wide alley in both 2014 and 2015. In conclusion it was found that a minimum 4m alley treatment or wider would be recommended for this alley coppice system in Ireland.

Use of smear cheese bacteria and yeasts to modify flavour and appearance of Cheddar cheese

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The aim of this study was to determine the ability of smear cheese bacteria and yeasts to grow on the surface of Cheddar cheese and thereby modify the flavour and appearance and reduce the ripening period. The strains of *Staphylococcus saprophyticus* DPC5671 and *Corynebacterium casei* DPC5298[T] were applied separately, in combination with *Debaryomyces hansenii* DPC6258, to the surface of young Cheddar cheese, to obtain two different varieties of smear-ripened cheese. A surface microbiota developed over the incubation period, comprising both yeast and bacteria; Cryo-SEM and Pulsed Field Gel Electrophoresis (PFGE) confirmed that the inoculated strains of *S. saprophyticus* DPC5671 or *C. casei* DPC5298[T] were the dominant strains on the surface of the cheese at the end of the ripening period. The smear cultures changed the appearance, the rheology and the aroma, which were significantly ($P<0.05$) different from the control cheese. The colorimetric analysis showed that the smear cheese produced with *D. hansenii* DPC6258 in combination with *C. casei* DPC5298[T] presented a significant ($P<0.05$) development of the red colour on the surface. Moreover, sensory and volatile analysis showed that the smear cheese produced with *D. hansenii* DPC6258 in combination with *S. saprophyticus* DPC5671 presented more volatile compounds, especially esters, and its flavour was more appreciated by the sensory panel. The approach presented in this study represents a potential method for the development of cheese varieties with reduced ripening times and novel aromas.

A dose-interval study of a dual probiotic preparation in preterm infants

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The aim of this study was to investigate the appropriate dosing interval of a two strain probiotic given daily, biweekly and weekly in preterm infants, < 32 weeks gestation. Stool samples were collected from 3 groups of preterm infants who received daily, biweekly and weekly doses of a probiotic (Infloran) containing *Bifidobacterium bifidum* (10^9 CFU/250mg tablet) and *Lactobacillus acidophilus* (10^9 CFU/250mg tablet). DNA was extracted from these stool samples at weeks 1, 34, 41 and 44 weeks post-gestational age (PGA). Faecal microbial composition was examined using 16S rRNA amplicon sequencing on the Illumina MiSeq platform. After first administration of the probiotic at day 7 (week1), faecal *Bifidobacterium* were significantly higher in the daily group (44.5%) in comparison to the biweekly (16.8%) and weekly (8.8%) groups, respectively. At 34 weeks PGA, faecal *Bifidobacterium* were significantly higher again in the daily (59.6%) group in comparison to the biweekly (21.4%), weekly (22.9%) and control (14.7%) groups. By 41 weeks PGA, a decrease in the relative abundances of *Staphylococcaceae* and *Enterococcaceae* were found in all three groups. Finally, at 44 weeks PGA, significantly higher levels of *Lactobacillus* were found in the biweekly group (16.5%) in comparison to the weekly group (2.1%). Our results indicate that a daily dose of Infloran is the most suitable dosing regime for preterm infants in the NICU, with significantly higher levels of *Bifidobacterium* found in the daily probiotic group when compared to the biweekly, weekly and control groups.

Goat milk oligosaccharides promote colonisation of *Bifidobacterium longum* subsp. *Infantis in vitro* in turn providing colonisation resistance against *Campylobacter jejuni*

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The numerous health benefits associated with bifidobacteria have led researchers to explore methods of promoting the colonisation potential of these beneficial bacteria in the gut. In recent times, the use of prebiotics which stimulates the growth of these microbes has been a main research focus for gut microbiologists with many different types of prebiotics on the market. However, the introduction of bioactive compounds from milk which can increase the colonisation potential of these strains is also gaining interest. Colonisation of the intestine with bifidobacteria is associated with a number of health benefits including increased digestion, protection from pathogen colonisation, reduced gastric transit time and improved immune function. In this study, goat milk oligosaccharides (GMO) were examined for their ability to promote the adhesion of bifidobacteria to human gut epithelial cells. Colonisation assays were performed and the GMO's were found to promote adhesion of the bifidobacteria by up to 8-fold. We also demonstrated that by promoting the adhesion of bifidobacterial strains to intestinal cells, a 39% decrease in adhesion rates of the pathogen *Campylobacter jejuni* 81-176 resulted. This study provides insight into the role milk components play in the development of a healthy microflora, which in turn has a protective effect against pathogen colonisation.

Clinical Outcomes of Real-World Kalydeco (CORK) study- Investigating the impact of CFTR potentiation on the intestinal microbiota, exocrine pancreatic function and intestinal inflammation prospectively over 12 months

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Ivacaftor is effective in the treatment of patients with Cystic Fibrosis carrying the G551D gating mutation. We present faecal analysis results of the CORK cohort, a single-centre, adult, prospective, longitudinal study of G551D clinical responders (median follow-up 12 months), examining the gut microbiota, exocrine pancreatic function and intestinal inflammation on a 3 monthly basis after commencing treatment.Stool samples were collected at pre- and 3 monthly timepoints post commencement of Ivacaftor from 18 adult patients and subsequently underwent metagenomic profiling of faecal microbiota. Faecal elastase-1, faecal calprotectin and faecal lactoferrin were evaluated for each patient pre and post Ivacaftor. Ivacaftor did not significantly alter gut microbial diversity, as measured by chao1 ($p=0.886$). Changes were observed in the relative abundance of taxa at phylum (increasing Bacteroidetes and decreasing Firmicutes), family (increasing Bacteroidaceae ($p=0.064$) and decreasing Enterococcaceae ($p=0.055$) and genus (increasing *Bacteroides* ($p=0.064$), *Parabacteroides* ($p=0.013$) and decreasing *Enterococcus* ($p=0.055$) levels. No significant difference was measured in levels of Faecal elastase-1 ($p=0.999$), faecal calprotectin ($p=0.235$) or faecal lactoferrin ($p=0.296$). Ivacaftor treatment alters gut microbiota composition at phylum, family and genus levels. Elevated intestinal inflammation was sustained. Lack of exocrine pancreatic recovery may reflect established exocrine pancreatic dysfunction in an adult cohort. On-going longitudinal prospective data may demonstrate further improvements in the gut health of this cohort.

Dairy food structures influence the rate of digestion through different in vitro gastric behaviour

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The behaviour of food structures during digestion has been seen to play a crucial role in the modulation of postprandial satiety-related responses. The aim of this study was to determine *in vitro* the extent to which specific food structures alter gastric behaviour and could therefore impact on nutrient delivery and digestion in the small intestine. Two dairy-based foods with the same caloric content but different structure were studied, cheese/yogurt mixture (semi-solid meal) vs. liquid dairy emulsion (liquid meal). The results were obtained from a specifically developed gastric digestion model based on a human trial in which the same meals were studied. The semi-dynamic model could simulate the main gastric dynamics including gradual acidification, lipolysis, proteolysis and emptying. The findings showed similar gastric behaviour to that seen previously *in vivo*. Gastric behaviour was affected by the initial structure with creaming and sedimentation observed in the case of liquid and semi-solid samples, respectively. Lipid and protein digestion profiles showed clear differences in the amount of nutrients reaching the small intestine and, consequently, the likely bioaccessibility after digestion. The semi-solid sample generated higher nutrient release into the small intestine at an early stage of digestion whereas nutrient accessibility from liquid sample was delayed due to the formation of a cream layer in the gastric phase. This shows the strong effect of the matrix on gastric behaviour, proteolysis and lipolysis, which explains the differences in physiological responses seen previously with these systems in terms of fullness and satiety. This study will improve the understanding of the link between food structure, gastro intestinal flow and nutrient sensing which will allow the development of food with improved and/or tailored biofunctional properties addressing health concerns.

Understanding the driving factors behind low molecular weight phlorotannin variation in commercially valuable Irish brown seaweeds - a fundamental step towards future exploitation

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The potential of highly bioactive polyphenols, phlorotannins, for commercial application has long been recognised, particularly within the food industry, due to the many associated health benefits reported including anti-oxidant, anti-inflammatory, radio-protective, and anti-diabetic activity, making them highly attractive compounds for industrial extraction. Phlorotannins can constitute up to 5-12% of dry weight in particular brown algal species, functioning as chemical defences against several environmental stressors. However, phlorotannins possess a high degree of phenotypic plasticity responding to environmental changes, resulting in seasonal and temporal variability. Until recently, spectrophotometric assays have been the primary method for phlorotannin quantification. However, these methods provide no qualitative information on the phlorotannin composition in regard to their metabolic profiles. The main objective of this work is to, through the employment of novel mass spectrometric methods (UPLC-TQD-MS/MS, Q-ToF-MS), assess the structural variability onset by varying environmental parameters, in an effort to elucidate on the factors driving their production. Through both continuous field sampling and lab controlled experiments, a thorough assessment of the primary abiotic factors impacting upon phlorotannins was achieved. Interspecific variations between species differing in their vertical position along a shore gradient, and thus degree of exposure to environmental stressors, were observed resulting in unique metabolic profiles for each species. Intraspecific variability within an individual species was observed with tissues contributing most to fitness exhibiting a higher concentration. Extrinsic factors, primarily irradiance (confirmed by *in vitro* experiments), impacted seasonal variations as did intrinsic factors such as developmental stage within a species life cycle. Future investigation on specific environmental factors (including biological relationships) will provide further insight to the regulation of phlorotannins within brown algae.

The incorporation of colourant into cheese curd by high pressure processing

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During manufacture of coloured cheddar cheese, approximately 20 % of the colourant added (typically natural compounds such as Annatto) is lost in the whey stream, and thus may be incorporated into subsequent whey products. This creates a challenge in terms of the growing market demand for coloured cheese and the parallel growing and lucrative global market for high quality whey protein ingredients which do not contain colourants. Although permitted in the United States, the removal of colour from the whey stream by bleaching is prohibited in Europe and in Asia, and thus there is a need to develop processes to facilitate the manufacture of coloured cheese without compromising the whey stream value. In this study, the first objective was to investigate if high pressure (HP) processing could enhance penetration of colour into the cheese curd after removing the main body of whey. The second objective was to characterise whether a combination of HP treatments (250 or 400 MPa) and colourants (Annatto; β-Carotene) affected gross composition, texture and microstructure of cheese, or influenced colour penetration into the curd, as assessed by using 3D computer analysis, over a 30 day ripening period. The results indicated no significant differences (P>0.05) in composition resulting from the various treatments; similar microstructures were also observed for both pressure-treated and control curd samples. Over the 30-day ripening period, hardness decreased in the control and pressured-treated curd samples, and proteolysis (pH4.6-soluble Nitrogen, Urea-PAGE) increased over ripening, but was not affected by the various treatments. Furthermore, computer generated images revealed that the colour remained localised at the curd's surface/rind directly after the pressure treatments and after the 30 day ripening period.

Front-face fluorescence spectroscopy for identification of dairy ingredients

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Identification of dairy ingredients is of critical importance for quality control and safety in food product manufacture. The objective of this study was to investigate the use of spectral process analytical technology (PAT) tools, such as front face fluorescence spectroscopy (FFFS), for identification of a range of non-agglomerated dairy ingredients. FFFS has been used previously for analysis of protein denaturation and Maillard reaction in liquids. The study investigated the use of FFFS at excitation wavelengths sensitive to protein denaturation, Maillard browning and riboflavin. The experimental design consisted of 3 dairy ingredients, namely skim milk powder, 35% whey protein concentrate powder and 90% demineralised whey powder. The ingredients were manufactured at a range of heat treatments, prior to spray drying under constant conditions. The spectral response patterns from fluorophore interactions enabled discrimination of processed dairy ingredients. The results demonstrated that FFFS, with multivariate data analysis, can be used to differentiate between dairy ingredients.

Quantifying and controlling the crystallisation behaviour of phytosterols in functional dairy systems

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Dietary plant sterols, or phytosterols, have been shown to lower low-density lipoprotein (LDL) cholesterol in humans, and to possess anti-inflammatory and anti-carcinogenic properties. Like many other bioactive compounds, their bioaccessibility for human absorption is dependent upon their crystallinity within their carrier matrix. Food lipids, such as milk fat, provide an opportunity to limit the crystallisation of such bioactive molecules, due to the lipid's ability to form rigid triacylglycerol lamellar structures. Thus, this study examined the mechanism of phytosterol crystallisation within milk fat and how crystallisation can be controlled to improve the bioaccessibility of the phytosterol. The crystallisation behaviour of phytosterol-enriched (PE) emulsions was measured as a function of temperature using differential scanning calorimetry (DSC) and synchrotron x-ray diffraction. Particle accelerating synchrotrons are not commonly used in food science but are crucial when studying angstrom level details within multicomponent food systems. Synchrotron data demonstrated that phytosterol crystals can integrate within a triacylglycerol (TAG) network but do not influence the overall triglyceride lattice parameters. DSC profiles demonstrated that, at higher levels of plant sterol addition, crystallisation onset was delayed while, at lower levels, their presence resulted in nucleation of emulsion crystallisation. In order to control phytosterol crystallisation, formulation and processing parameters of the phytosterol-enriched emulsion were varied. Crystallisation in droplets of two different particle sizes, at two different concentrations of phytosterol enrichment with either lecithin or distilled monoglycerides, were studied using synchrotron x-ray diffraction and optical backscattering. Results demonstrated that the processed smaller droplets within added lecithin had a more disordered triacylglycerol matrix and less crystalline phytosterol. By understanding the mechanism and behaviour of phytosterol crystallisation, the functional food industry will be able to improve the stability and bioaccessibility of phytosterol-enriched food products.

The effect of covalent labelling techniques on the properties of dairy protein stabilised emulsions

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Oil-in-water emulsions are common in dairy products. Emulsion stability is determined by compositional and processing parameters, in particular the adsorbed layer at the oil-water interface. Confocal laser scanning microscopy (CLSM) is widely used to visualise emulsions and studies have shown that it is possible to stain proteins and fats by passive labelling using various fluorescent probes/dyes. However, these general labelling techniques do not distinguish different proteins within the interfacial layer. In this study, β-casein was stained with NHS-Rhodamine [5-(and 6) - carboxytetramethylrhodamine, succinimidyl ester] via covalent labelling. Pre-labelled β-casein conjugates were analysed by absorbance and fluorescence spectroscopy to achieve the optimal degree of labelling. The spectra scanning showed that there was a little red shift in the absorbance spectrum peak of NHS-Rhodamine (554nm) with splitting into two absorption peaks at about 520nm and 556nm. Standard emulsions with 0.5% total protein (WPI and β-casein with or without label, 1:1/w/w) and 10% fat (sunflower oil) were produced. The effect of conjugating β-casein with NHS-Rhodamine on the physicochemical properties of emulsions was investigated using spectrophotometry, laser-light scattering, multisample analytical centrifuge, rheology, tensiometry and CLSM. Results indicated that the presence of pre-labelling had a minimal effect on the droplet size distribution, surface charge, interfacial tension and viscosity of β-casein and WPI based emulsion. Confocal micrographs illustrated that the mixed proteins on the interface were able to be co-localised via covalent and non-covalent labelling techniques.

Influence of lactose content and water plasticization on flavour release from spray-dried amorphous matrix

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Glass-forming carbohydrates are widely used as a matrix for encapsulation and stabilization of nutrients and bioactive compounds. In this study, encapsulation systems with lactose/whey protein isolate (WPI) mixtures at ratios of 4:1, 1:1, or 1:4, or only WPI as wall materials and ethyl butyrate as core material were prepared by spray drying. The effects of lactose content and water plasticization on encapsulation efficiency and flavor release were investigated. Particle size of powders with higher amount of lactose was smaller, and wall material consisting of lactose/WPI (4:1) mixture had significantly ($P < 0.05$) higher encapsulation efficiency than wall systems consisting of only WPI. However, wall materials with lactose/WPI mixtures at ratios of 1:1 and 1:4 did not show similar results. The flavor retention in encapsulation systems did not have significant decrease with equilibration at 0.33 a_w for 216 h. But encapsulation systems with wall materials consisting of a higher amount of lactose showed dramatic decreases in their flavor retention, with equilibration at 0.54 a_w and 0.65 a_w, which was as a result of lactose crystallisation. Mechanical property study indicated that powder with a higher amount of lactose showed higher molecular mobility with increasing water content, and water plasticization had more significant impact on the glass transition and structural relaxation of powder with a higher amount of lactose. Therefore, increasing lactose content could increase the encapsulation efficiency of wall materials during spray drying. However, this also could result in a higher rate of flavor release with storage at high water activity.

Molecular mechanism of protein aggregation in milk protein concentrate

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Heat treatment is an essential processing step in the manufacture of milk protein ingredients. It is also known that pre-heat treatment of proteins improves their thermal stability. During heating, milk proteins interact to form nanoparticles of caseins and whey proteins. In particular, κ-casein, one of the four caseins in milk, is thought to stabilize whey proteins during heating of milk. In this study, colloidal particles of heated milk protein concentrate were isolated by size exclusion chromatography. The collected fractions consisted of whey proteins and caseins at different ratios, ranging from 0.1:1 to 1.5:1. The heat stability of each fraction was assessed and was found to correlate with the casein concentration in the samples. The samples containing the highest ratio of caseins were the most heat-stable and close to 100% of the soluble aggregates were recovered. κ-casein appeared to act as a chaperone for the aggregation of whey proteins together with α- and β-casein. The results of this study have the potential to improve the heat stability of nutritional beverages by fine-tuning the casein to whey protein ratio.
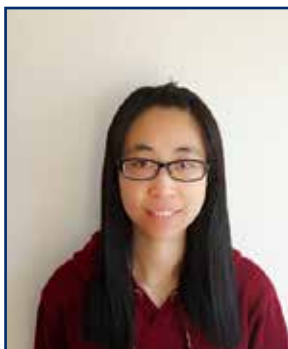
Effect of different operations during manufacture on the properties of skim milk powders

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Skim milk powder is one of the most important protein ingredients with a wide range of applications such as beverage, recombined milk, resembled 'milk' for cheese and yoghurt, which require the functional properties of rennet gelation and heat stability of the skim milk powder. The current study investigated the changes in composition and aggregation behaviour of milk at the different stages of manufacture of low-heat (72¡C ´ð15 sec) and high-heat (120¡C ´ð 2 min) skim milk powders (LHSMP, HHSMP). The following samples were taken during the manufacture: skim milk before and after heating, concentrate at 25% and 45% total solid (TS) on evaporation and powder after drying; both the concentrate (45% TS) and powder were diluted/reconstituted back to the same solids as the skim-milk before heat treatment. The heat coagulation time (HCT) was measured across the pH range of 6.2 to 7.2 and at natural pH of milks and diluted concentrates at 140 ¡C. HCT of concentrates (25% TS) were determined at 120 ¡C in the pH region of 6.0 to 7.0 and at natural pH. High heat during the manufacture of SMP caused the failure in rennet-induced gelation and shifted the pH maximum HCT from 6.7 to 6.6. These effects of high heat treatment were associated with increases in whey protein denaturation and kð-casein as % of serum casein. Apart from the temperature during milk heat treatment, the other steps involved in the manufacture of SMP, i.e., evaporation and drying, also influenced the rennet gelation but had little effect on composition and heat stability of the diluted concentrate.

Development of protein-enriched restructured beef steaks for elderly consumers using the PiVac technology

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Protein-enriched foods can play a role in reducing the risk of sarcopenia in the elderly. The PiVac meat wrapping technology may offer considerable potential in the development of low-cost, controlled portion size and softer texture restructured beef products. The technological properties of raw and cooked restructured steaks enriched in clean label protein ingredients in combination with PiVac were investigated. A screening study was conducted on lean restructured steaks (95% VL) formulated with pea protein isolate (PPI), rice protein (RP) and lentil flour (LF) at two inclusion levels (4% and 8%) and two binding agents: Activa[EB] 1% (TG), and Trangluseen[TM]-M 0.15% (TS). Protein content in RP8TG was significantly higher than controls in both the raw and the cooked state. Raw LF4TS exhibited greater ($P<0.01$) a* values than control steaks. However, after the cooking process L*, a* and b* values were similar for all treatments. According to bind strength, the favourable conditions for binding the restructured steaks were 8% PPI in combination with TG. Textural profile analysis (TPA) results showed that elevating protein level increased ($P<0.001$) hardness, chewiness, cohesiveness and gumminess in cooked restructured steaks. The lowest ($P<0.001$) TPA values were obtained for LF treatments, indicating a strong plant protein effect on texture modification. Overall, Activa[EB] binder performed best in combination with protein ingredients and would facilitate the production of restructured steaks with acceptable quality from low-value beef muscles. PiVac technology shows potential for developing protein-enriched restructured beef steaks; however, future studies should include sensory evaluation to assess acceptability among elderly consumers.

Monitoring *Listeria monocytogenes* occurrence, persistence and patterns of contamination in Irish ready-to-eat food processing environments over a three-year period

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Listeria monocytogenes should be carefully monitored in food processing facilities, especially those which produce ready-to-eat foods, in order to reduce the risk to public health by contamination of food. Over three years, beginning in March 2013, 35 food processing facilities were monitored for *L. monocytogenes* occurrence. Every two months, food processors sent a sample set, generally six environmental swab samples and two food samples, for *L. monocytogenes* analysis by ISO 11290-1*.* Based on results generated, advice was given to food business operators concerning any contamination found and methods to help reduce this contamination. In total, from 3,864 samples analysed, 175 *L. monocytogenes* positive samples were found. The total prevalence rate of *L. monocytogenes* was seen to decrease over the three years of sampling: 5.2% in Year 1, 4.5% in Year 2 and 4.1% in Year 3. The rate of positive food samples by year varied from 5.4%, to 6.6% and 2.8%, respectively, by year. *L. monocytogenes* strains isolated were further characterised by serotyping and pulsed field gel electrophoresis (PFGE) to allow identification of persistent strains and patterns of contamination. Isolates identified included, in order of prevalence, serotypes 1/2a (45%), 4b/4e (29%), 1/2b (17%) and 1/2c (9%). 75 distinct PFGE pulsotypes were identified throughout the study. Persistent strains, i.e. indistinguishable PFGE pulsotypes found at least six months apart, were identified in 10 food processing facilities tested. The results demonstrate that awareness of *L. monocytogenes* can help reduce its occurrence and lead to improved public health.

Development of high throughput methodology for extracting drug residues from food using vibrational shaking and LC-MS/MS

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The objective of this research was to develop a rapid UHPLC-MS/MS test for the detection of residues in food, using an automated vibrational shaking apparatus and ceramic homogenisers. The introduction of this novel automated high-throughput method in residue analysis was carried out to enhance the safety of our food and ultimately improve consumer confidence. This novel sample preparation approach allowed for the unattended homogenisation of 36 samples simultaneously, versus the six sample capabilities of QuEChERS. In addition, the probe homogenisation of samples, followed by probe cleaning after each sample, required approximately 55 minutes. Homogenisation time was reduced to just eight minutes with the introduction of automation. The automated shaking system was also employed in the QuEChERS extraction step of the method, to allow more consistent shaking of samples, elimination of salt aggregation, enhanced extraction efficiencies and method precision. Overall, these modifications reduced the time-consuming sample preparation step and improved sample efficacy and repeatability, in this new high-throughput anthelmintic residue method. The method suitability of the new automated extraction procedure was evaluated using fortified and naturally incurred tissue samples, showing that the vibration shaking procedure was comparable or better than probe homogeniser method for many analytes. The developed methodology was extended to include a number of new analytes, allowing < 50 analytes to be analysed in a single run, at levels as low as 1 µg kg^{-1}.

Exploring the decision processes of Irish farmers in the adoption of GHG mitigation options

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Irish agriculture has an important role in efforts to meet national Greenhouse Gas (GHG) emission targets. A number of farm management practices to mitigate GHG emissions are available, but even where it is profitable for the farmer to do so adoption rates have been relatively low. Research to better understand the adoption decision has focussed on identifying farm/farmer characteristics associated with increased probability of adoption. While useful, this research is context specific. Using new survey data of Irish farmers, this paper explores the adoption decision across six different GHG mitigation options, utilising a range of econometric models to provide a more complete understanding of the adoption decision. In the first stage of this work, the drivers of adoption were considered across three broad categories of variables: farm/farmer characteristics; knowledge and attitudes; sources of knowledge and information. Along with a number of relevant farm/farmer characteristics, the results identified knowledge and attitudes as an important factor in the adoption decision. While the majority of adoption studies end here, this work considers a second stage: the drivers of farmers' knowledge and attitudes. The results identified different sources of information impacting on knowledge of, and attitudes towards, GHG mitigation options. This formed the basis for the third stage, understanding where farmers access knowledge. The results revealed important interactions between different sources of information, including multiple sources, but also farmers' attitudes impacting on information channels chosen. Reducing GHG emissions in agriculture via the adoption of different management practices and technologies relies on the individual decisions of thousands of farmers, i.e. changing behaviours. This research highlights the complexity of this decision process, with multiple factors driving adoption, but changing as the mitigation option changes. The results suggest more nuanced policy interventions are necessary, including changing knowledge and attitudes, with specific sources of information driving this change.

Consumer assessment of unmet needs in the development of targeted and appropriate novel food for the older population.

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The world's population is increasing in age with healthy ageing becoming an increasingly pertinent issue. Few food products currently exist on the market that are specifically formulated for older consumers to meet their nutritional and physical needs. The aim of this research is to identify new product opportunities for this group to enhance their potential for healthy ageing. First, the Mintel Global New Products Database was reviewed to examine products launched and marketed towards the older consumer in the last year. Then, an "Attitudes and Food Choice" questionnaire was used for quantitative research in a sample of 128 community-living over 65s, with a mix of genders, socio-economic status and health conditions. The majority of products marketed towards this consumer were launched on the Asian market, with few products launched in Europe. The most frequent health claim was vitamin fortification and the most common food types were meal replacements, prepared meals and milk based drinks. 68% of participants sampled claimed they would be willing to pay more for healthy foods. However, almost half said they would be unlikely to buy "functional foods". Conversely, when then given examples, 75% were already using functional foods. Finally, over half reported difficulty in reading (55%) and understanding (52%) food labels

There is both a market need and demand for functional foods with a significant amount of untapped potential for the Irish food industry to explore. Consideration needs to be given to communication message about these products. In addition, the daily obstacles faced by this age group when using food products needs to be recognised as these can result in impaired nutritional and functional status. These findings have the potential to influence public health and nutrition policy developments in Ireland.

Attitudes to land mobility in Irish agriculture

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Functioning land markets play an important role in any agricultural economy. This is especially the case in countries with pastoral, grass-based agricultural systems, such as Ireland. However, Irish land markets are relatively static, despite growing land demand. This study examines attitudes amongst Irish farmers toward land mobility, as well as openness to various forms of land transaction. Our analysis is based on a nationally representative survey of 846 Irish farmers. A logit model is used to examine farmers' willingness to enter the land market through leasing in land, leasing out land, buying land or selling land.

Results show that farmers were more open to adding land than releasing it, with 50% willing to add land and 25% willing to release land. Four attitudinal variables were identified and were predictive of willingness to enter the land market. Farmers motivated by the pleasure of farming were more likely to demand land while farmers of an innovative nature were more likely to be willing to supply land. Conservative farmers were unlikely to be open to either supplying or demanding land. Dairy farmers and farmers with a high stocking rate were open to adding land while cattle farmers were more open to supplying land. Other factors such as age, income from farming and the presence of a successor influenced farmers' willingness to enter the land market. Contrary to popular belief, farmers are willing to enter the land market on both the supply and demand sides in Ireland. This research may help policy makers identify farmers open to entering the land market and facilitating land transactions that are not currently taking place.

Estimating the economic returns of the beef technology adoption programme

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Financially rewarding farmers is an unconventional approach to agricultural extension, an approach that has been adopted by the Irish government. The Beef Technology Adoption Programme (BTAP) was a government-funded extension program that was primarily delivered through farmer discussion groups from 2012 to 2014, which rewarded participating farmers with conditional cash transfers. In this study, the economic returns to participating farmers are estimated. As with all evaluation studies of non-randomised programs, differences between participants and non-participants cannot be solely attributed to the program. Differences between these two groups can exist prior to the commencement of the program. Additionally, as participation was on a voluntary basis, endogeneity problems due to self-selection bias may exist. To control for the endogeneity problem and to obtain a comparable control group, we use a propensity score matching model combined with the difference in difference approach. Applying the model to farm level data from the Irish National Farm Survey, our results indicate that BTAP participation had no significant impact on a farmer's economic performance over a four year period. Therefore, the conditional cash transfers can be considered a windfall gain for participating farmers. The results align with previous research on extension program evaluation and would suggest that extension programs with conditional cash transfers do not have a short-term impact. However, the longer term impacts of such targeted programs cannot be evaluated yet due to the short period of data available.
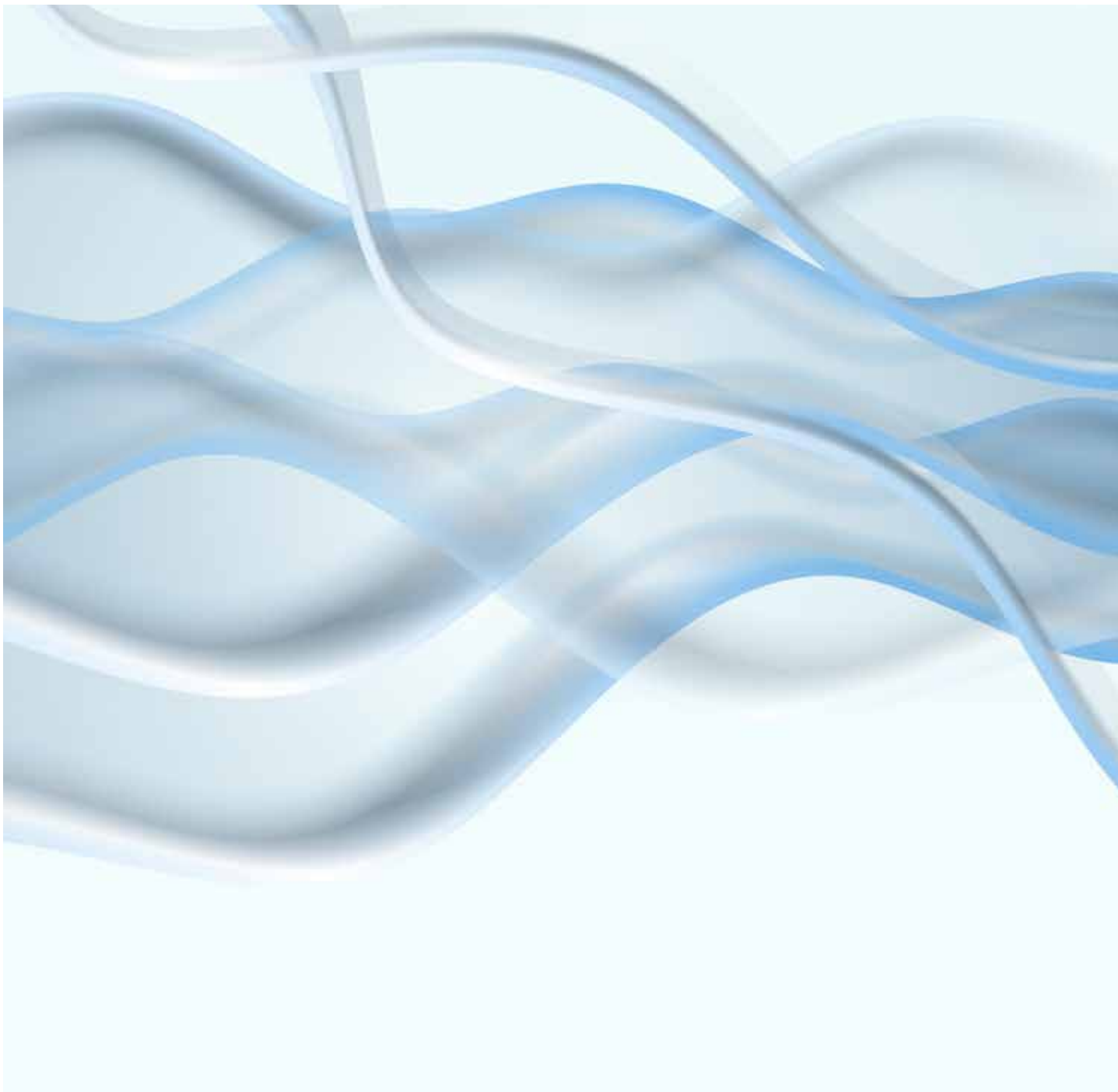
Measuring and understanding resilience in rural communities, the financialisation of farm households

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The international financial crisis of 2007/8 has manifested the increasing exposure of rural economies to exogenous disturbances caused by fluctuating and unpredictable global markets. Furthermore, emerging literature suggests that economic downturn is protracted in rural communities, extending into the longer-term due to structural unemployment, where employment that is lost remains unlikely to return. This is due to smaller labour markets, whose infrastructure is divided, and whose networks are less integrated causing the dynamics of supply and demand to have disproportionate effects in rural communities, with even minimal employment loss having detrimental effects in local communities. In order to understand how rural economies can become more resilient to continuing economic uncertainty, it is imperative to measure and understand varying degrees of resilience in rural communities. Therefore, the study aims to explore the impact and coping mechanisms of rural households through the application of a novel socio-economic model which brings together various schools of literature to generate a model capable of being applied to alternative economic contexts and scenarios. The model makes a significant contribution to both the theoretical and analytical understanding of socioeconomic change in the rural communities of developed nations. A comprehensive household instrument based on this model was administered to a representative sample of 386 farm and non-farm households in rural Ireland across three case study locations chosen to reflect potentially high, moderate, and low resilient areas based on an analysis of employment rate change during the years 2006 – 2011. Preliminary findings indicate that levels of resilience differ significantly between location, but not between farm and non-farm households per se, although farm households did report significantly greater difficulty in their ability to meet monthly loan payments relative to non-farm households. In relation to this, farm households were also more likely to have loans, pay higher loan payments, and have seen their loans increase significantly since the 'height of the economic crisis', compared to non-farm households. This points to the increasing financialisation of farm households in recent years, a process which has continued since the economic crisis, an important development to understand since preliminary results indicate a significant relationship between a household's level of resilience and its level of financial literacy.

Notes

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