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Nutritional management strategies to optimise annual sow output and to promote the growth and development of progeny from large litters

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Genetic selection for increased sow prolificacy has resulted in a major increase in litter size at birth. However, this is positively correlated with a higher proportion of low birth-weight piglets per litter and reduced piglet vitality, growth, and survival. The objective of this thesis was to investigate targeted sow nutritional strategies during gestation and lactation that were hypothesised to optimise sow productivity and to increase the birthweight and lifetime growth of offspring. Nutritional strategies investigated included: The effect of L-carnitine supplementation and sugar beet pulp inclusion in gilt gestation diets, the effect of L-carnitine supplementation to multiparous sows during gestation and/or lactation, and the effect of increasing sow lactation dietary energy density from 13.8 to 15.9 MJ DE/kg was determined. Sow and gilt measurements were recorded during gestation and lactation, and the growth performance of sow offspring was monitored from birth until slaughter. L-carnitine supplementation to gilts increased the live-weight, carcass weight and muscle depth of progeny at slaughter, and feeding a high- sugar beet pulp diet increased the carcass quality of progeny at slaughter. Findings from the second study showed that L-carnitine supplementation to multiparous sows during gestation increased litter size at birth, without compromising piglet birth-weight. Results also indicated that the *semitendinosus* of female piglets born to sows supplemented with L-carnitine during gestation was more developed at birth. Increasing the energy density of the lactation diet increased the energy intake in sows without depressing sow appetite and increased piglet vitality at birth. The maternal feeding strategies applied in this thesis could be utilised by commercial swine producers to increase litter size and pig carcass quality at slaughter, in addition to satisfying the energy requirements of high-performing lactating sows that are nursing large litters. This research may help to ameliorate some of the negative consequences of increased sow litter size.

Piece of cake? Unravelling the contribution of sugar and fat to the desirable flavour of baked confectionery products

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Due to the prevalence of diet related chronic diseases, baked confectionery products have become a major focus for reformulation. Reformulation proves challenging as many studies show a decline in consumer satisfaction with sucrose/fat replacement. Understanding volatile formation in these reformulated products can aid our understanding of the factors contributing to aroma, and thus sensory perception. The primary objective of this work was to elucidate the contribution of sucrose and butter to the desired flavour and aroma of baked confectionery products. To identify important volatile compounds, a headspace solid phase micro-extraction gas-chromatography mass-spectrometry method was developed and optimised. The method was applied to 'clean label' sucrose reduced sponge cakes, and shortbread biscuits formulated with Irish butter. Aroma active compounds were identified and sensory quality was evaluated. Key findings of this study show that sucrose replacement significantly impacts on the development of Maillard reaction and caramelisation aroma compounds, which influenced flavour perception by consumers. Shortbread biscuits formulated with Irish butters; produced from cows on pasture or concentrate diets, differed primarily on texture quality, due to the difference in milk fatty acid profile as a result of diet. This study demonstrates that combining volatile profiling and sensory techniques can aid in the understanding of the impact of raw materials, and their interactions on aroma and flavour development in reformulated products.

Emerging organic contaminants in Irish groundwater: investigating the occurrence of veterinary pharmaceuticals

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Due to increased intensification of the food production system, agrochemicals such as veterinary pharmaceuticals have become a critical component in animal husbandry in Ireland, and more broadly throughout Europe. Administration of these compounds can potentially lead to their occurrence in the environment. This work specifically focuses on two groups of antiparasitic veterinary agents commonly used in Irish agriculture, namely anthelmintics and anticoccidials, with an overall aim to examine their occurrence in Irish groundwater. There is very limited information available on the occurrence of these compounds in the environment, particularly in groundwater, which has resulted in them being considered as emerging organic contaminants (EOCs). Two comprehensive, highly sensitive, analytical methods were developed, validated and applied to investigate the spatial occurrence of 40 anthelmintic residues and 26 anticoccidial compounds, respectively, in groundwater samples. Sampling sites were selected to be representative of different animal production systems and hydrogeological settings throughout Ireland. During spring 2017, 106 sites were sampled for anthelmintic residues, with 16 different anthelmintics detected across 22% of sites. Detections were of the order of 1 - 41 ng L^{-1}. In a separate study during autumn 2018, 109 sites were sampled for anticoccidials, with seven different compounds detected at 24% of sites, with concentrations in the range of 1 – 390 ng L^{-1}. Multivariate statistical analysis has indicated that source factors are the most significant drivers of the occurrence of anticoccidials, with no clear relationship between occurrence and pathway factors. Overall, this work presents some of the first detections of these contaminants in Irish groundwater. Such detections indicate that these contaminants may require more appropriate consideration with regard potential groundwater quality and environmental concerns, given that their use is anticipated to continue, if not increase, as a result of agricultural intensification and climate change.

Assessing impact of seasonal weather extremes on farm feed use in Irish dairy farms

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Livestock farming in Ireland is a grass-based system which is a key to farm profitability and competitive production ability over other European Union countries. With the increase in the frequency of weather extremes in recent years, there is a considerable threat to pasture production in Ireland, subsequently affecting the farm productivity and animal performance. This research aims to understand and quantify the relationship between variations in supplementary feed usage in response to seasonal weather extremes in dairy farms using meteorological models and remote sensing data in a geographic panel analysis for the period 2001-2015. The fixed effect concentrate model results reveal that an extra one day of cool temperature in spring increases concentrate use in the farm by 8.82kg/Livestock Unit (LU) which is equivalent to 441kgs for a farm of 50 cows. The farms that are located in the south use less quantity of concentrates in comparison to the farms in the north. Early calving dairy farms use 126 kg/LU less concentrates annually when compared to winter milk farms. This developed explanatory model can be expanded to develop a forecast model to quantify the fodder needs for the national herd. The outcome of this research will enable to develop more robust Spatio-sectoral farming strategies to adapt to weather variations.

Animal & Grassland Research and Innovation Programme

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The effect of white clover inclusion into perennial ryegrass sward on in vivo digestibility, dry matter intake, dairy cow milk performance and dairy farm profitability

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Recent increases in milk price and fertiliser cost volatility are encouraging pasture based farmers to incorporate more sustainable approaches to producing herbage and milk. The incorporation of white clover (clover) into grass only swards has shown increased dairy cow milk and herbage production compared to grass only based swards. The objective of this thesis is to examine if the inclusion of clover can increase herbage digestibility, productivity, animal dry matter intake (DMI), dairy cow milk production and total farm profit of intensive pasture based spring milk production systems. In the first part, housed sheep were used in a comparison of the *in-vivo* digestibility of grass-only and grass clover in spring, summer and autumn. Sward clover content significantly increased OM and N digestibility compared to grass-only sward. The following chapter shows data from a four year (2013 to 2016) grazing systems experiment with three treatments was compiled. The three treatments were grass-only receiving 250 kg N ha^{-1} year^{-1}, grass clover receiving 250 kg N ha^{-1} year^{-1} grass clover receiving 150 kg N ha^{-1} year^{-1}. Individual dairy cow DMI was measured in May, July and September each year, using the *n*-alkane technique. Milk yield was measured daily during the same periods, and the milk yield potential and UFL balance were calculated. There was no effect of treatment on herbage DMI, milk yield and milk solids yield was greater (*P*<0.001) on the two grass-clover treatments compared to grass-only, and the grass-only treatment had greater (*P*<0.05) UFL balance compared to the two grass-clover treatments. The same four years of data was then used in the Moorepark Dairy Systems Model to stimulate economic performance of a 40 ha dairy farm. The study found the mean milk sales and total farm profit were increased on the white clover treatments, on average +25,700 kg of milk and +€5,568 per farm. The experiments in this thesis provide evidence that the inclusion of clover into an intensive pasture based spring milk production system can have significantly positive effect on herbage digestibility, dairy cow production and farm profitability.

Strategies to improve the microbial quality of liquid feed and optimise growth of liquid-fed grow-finisher pigs

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The objectives of this thesis were to (1) characterise the microbiological quality of liquid feed on Irish pig units; (2) control spontaneous fermentation during liquid feeding using controlled fermentation and dietary acidification; (3) compare feed form and delivery in grow-finisher pigs; (4) determine the optimum water-to-feed ratio for grow-finisher pigs. A survey of eight commercial pig production units was conducted, in which spontaneous fermentation and amino acid degradation were found in liquid feed. Controlled whole diet fermentation and cereal-only fermentation were then compared to fresh liquid and wet/dry feeding of the same diet. Feeding a fermented whole diet reduced pig growth and caused feed conversion efficiency (**FCE**) to deteriorate. As no benefits were found for fermentation, feed form (meal, pellets) and delivery methods (dry, wet/dry, liquid) were compared. The conclusion was that wet/dry feeding of a pelleted diet to grow-finisher pigs optimises growth and FCE. In an attempt to improve FCE in liquid-fed pigs, four commercially used water-to-feed ratios (2.4:1, 3:1, 3.5:1 and 4:1, dry matter basis) were compared. The 3.5:1 ratio optimised FCE without reducing kill-out percentage. Lastly, diets supplemented with benzoic acid (**BA**) at 0, 2.5, 5 and 10kg/t were liquid-fed to grow-finisher pigs. While BA inclusion stabilised liquid feed pH and controlled lactic acid bacteria **(LAB)** growth in troughs, no improvements in growth or FCE were observed; however, FCE was excellent for the control and hence a response to BA was unlikely. In conclusion, wet/dry feeding of a pelleted diet optimised growth and FCE in grow-finisher pigs. Spontaneous fermentation occurs during fresh liquid feeding and even controlled whole diet fermentation leads to amino acid degradation. To optimise FCE, a 3.5:1 water-to-feed ratio is optimal for short-trough liquid feeding of grow-finisher pigs. Benzoic acid stabilised liquid feed pH and controlled LAB growth but did not improve pig growth.

Fertility of sex-sorted sperm in seasonal-calving pasture-based dairy herds

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Use of X-sorted sperm increases the proportion of female dairy offspring from artificial insemination (AI); thus, it can be used to rapidly produce high numbers of dairy heifers, and has the potential to accelerate herd expansion and, through targeting elite females, increase profitability. However, sex-sorted sperm generally achieves poorer field fertility than conventional, unsorted, sperm. This limits its widespread adoption, particularly in pasture-based systems, which are highly dependent on reproductive efficiency to achieve compact calving at the beginning of the grass-growing season. During the last years, improvements in the sex-sorting technology have aimed to close the gap in field fertility between sex-sorted and conventional sperm. Given the potentially severe impact of poor fertility in a seasonal pasture-based system such as that operated in Ireland, there was a need to conduct field studies to evaluate the fertility of fresh and frozen X-sorted sperm under Irish conditions.

In the first study, we investigated the phenotypic fertility performance of dairy heifers and lactating cows inseminated after spontaneous oestrus with fresh (1 or 2 million sperm dose) or frozen (2 million sperm dose) SexedULTRA™ X-sorted sperm compared with fresh conventional sperm (3 million sperm dose) in seasonal-calving pasture-based dairy herds. X-sorted sperm achieved relative pregnancy per AI (P/AI) ranging from 78.4 to 88.9% of those achieved with conventional sperm. P/AI achieved with frozen X-sorted sperm did not differ from that achieved with fresh X-sorted sperm. Doubling the concentration of sperm in fresh X-sorted straws did not improve P/AI. There was a significant bull effect on P/AI in both lactating cows and heifers. Additionally, P/AI of lactating cows inseminated with fresh sperm (conventional and X-sorted) varied between bulls as dispatch-to-AI interval increased. Heifers had greater P/AI than lactating cows, and P/AI in lactating cows decreased with increasing parity. Among young cows (parity ≤ 2), the following cow characteristics were associated with greater likelihood of pregnancy establishment after insemination with X-sorted sperm: BCS ≥ 3, DIM > 60 d, and fertility sub-index of the EBI > €100.

In the second study, we investigated the phenotypic fertility performance of lactating dairy cows inseminated with frozen SexedULTRA-4M™ X-sorted sperm (4 million sperm per straw) compared with frozen conventional sperm (15 million sperm per straw) in seasonal-calving pasture-based dairy herds. Overall, P/AI was greater for cows inseminated with frozen conventional sperm than for those inseminated with frozen X-sorted sperm (59.9% vs. 45.5%; 76.0% relative to frozen conventional sperm). The effect of sex-sorting on P/AI was highly variable between bulls, with greater variation amongst bulls whose ejaculates were shipped to the sorting centre compared with resident bulls. Frozen X-sorted sperm resulted in greater relative P/AI in cows with high and average fertility potential (defined by parity ≤ 2, DIM at AI ≥ 70, EBI fertility sub-index > €60) than in cows with low fertility potential. In 33.1% of the

enrolled herds, the P/AI achieved with frozen X-sorted sperm was ≥ 90% of the P/AI achieved with frozen conventional sperm; this was primarily a reflection of herds that had excellent performance with frozen X-sorted sperm, but performed relatively poorly with frozen conventional sperm.

Although there is a growing number of calves derived from X-sorted sperm, relatively few follow-up studies have investigated whether sex-sorting had subsequent effects on calf and adult characteristics. A detrimental effect on health and productivity of offspring derived from X-sorted sperm, especially if female offspring are affected, could negate the advantages of a biased offspring sex ratio. In the third study, we compared perinatal and postnatal mortality as well as productive and reproductive performance of offspring derived from AI with X-sorted or conventional sperm processed from the same ejaculates. Calf survival during the first year of age was not different between animals derived from AI with X-sorted or conventional sperm. Male calves had higher mortality rates during the first 2 months of age than female calves independent of sperm treatment. No differences existed due to sex-sorting in reproductive or lactation performance of female offspring or in slaughter performance of steers and young bulls.

In conclusion, X-sorted sperm achieved lower P/AI than conventional sperm in seasonal-calving pasture-based heifers and lactating cows inseminated after spontaneous oestrus. However, P/AI achieved with X-sorted sperm was dependent on the bull, fertility potential of the cow, and herd. Offspring derived from conventional or X-sorted sperm did not differ for any of the performance characteristics studied, indicating that sex-sorting has no negative implications for offspring health and productivity.

Examining the interrelationship between milk storage and production conditions on milk and dairy products quality

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The Irish dairy industry has expanded significantly over the last five years since the abolition of the milk quotas in 2015. The Food Harvest Programme predicted that the milk production would increase by 50% by 2020. The expansion opportunity for Irish dairying has the potential to contribute greatly to the national economy; however, the consistent production of high quality dairy products in accordance with specific international quality parameters is essential to hold market share. The aim of this research is to investigate how production conditions on-farm can influence the microbiological quality and processing properties of raw milk, as well as how the quality of that milk can impact the manufacture and quality of dairy products. The research was divided in two parts, in the first part the studies were focused on evaluating the relationship between raw milk production conditions on-farm and quality, while in the second part the relationship between raw milk quality, processability and effects on the quality of dairy products were investigated. The research was divided into six studies, the specific objectives of each were: (i) to determine the effect of storage temperature and time on the microbiological and compositional quality of milk; (ii) to determine the effect of different pre-cooling rates on the microbiological load and composition of milk; (iii) to monitor the microbiological load of milk throughout a low-heat skim milk powder manufacturing process, from farm bulk tanks to final product; (iv) to investigate the seasonal differences in the levels of chlorate, perchlorate, trichloromethane, quaternary ammonium compounds and iodine in bulk tank milk and throughout a skim milk powder manufacturing process; (v and vi) to determine the effect of different levels of *Pseudomonas fluorescens* on the cheese-making properties of milk, proteolysis and quality of Cheddar cheese.

Mineral deficiency in flocks - prevalence, risk factors, supplementation strategies and impact on ewe and lamb performance

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The number of lambs reared per ewe joined is a key determinant of profitability on sheep farms. Mean weaning rate on Irish sheep farms has been relatively constant for the last 30 years. Furthermore, many producers are unable to finish all lambs from grazed grass as the sole diet. Whilst this may be due to a numbers of reasons, mineral deficiency must be considered. Mineral deficiency can reduce live weight gain, ewe reproductive performance and in turn farm profitability.

Study 1: **A survey of mineral supplementation and delivery strategies in Irish sheep flocks**

The aim of the study was to establish the mineral and vitamin supplementation practices on Irish sheep farms and farmer's knowledge and opinions in relation to supplementation strategies and mineral and vitamin deficiencies. A survey was undertaken in conjunction with the Teagasc NFS and was completed by farmers with a sheep enterprise. Sixty nine percent of respondents supplemented their flocks with minerals and vitamins in addition to concentrate feed. Most supplementation decisions are undertaken in the absence of veterinary advice or laboratory analysis.

Study 2: **A survey of the prevalence of mineral deficiencies on Irish sheep farms**

The objectives of this study were to establish the prevalence and seasonality of mineral deficiencies on Irish sheep farms. Herbage was sampled pre-grazing from 3 paddocks on 56 sheep farms across Ireland from March to November. Herbage mineral concentrations vary throughout the grazing season, Co and I supply from herbage is not sufficient on most sheep farms while Se and Zn supply is marginal or deficient on a large proportion of farms.

Study 3: **Effects of cobalt supplementation and method of supplementation on ewe reproductive performance and the performance of their progeny.**

The aim of the study was to evaluate the effect of cobalt supplementation and method of administration on ewe reproductive performance and the performance of their progeny. Ewes were allocated to one of three treatments; Control - no supplementation; Drench – Co supplementation via oral drench every 14 days or cobalt bolus from 7 weeks pre joining to 6 weeks prior to lambing. Supplementation with Co, either via drench or bolus, had no effect on ewe reproductive performance or the performance of progeny up to weaning.

The impact of field headlands on soil structure in Irish tillage fields

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Field headlands are integral components of agricultural landscapes and are used for the turning of agricultural machinery. Growers have adopted larger heavier machines which in a temperate maritime climate where field size can be small and irregular poses a threat to soil structure. Previous research has indicated differences between headlands and in-field areas. The aim of this research was to quantify the impact of headland turning traffic on soil structure using a zone approach. In the post-harvest period of 2016 and 2017, soil structure was examined on 40 plough-based arable fields across the main cereal growing region of Ireland and included a number of soil textures. A headland zone approach, as defined by the intensity of headland machinery traffic, was used to determine the location of soil measurements, which were replicated on transects across all zones at each site. Two visual soil evaluation techniques were used: Visual Evaluation of Soil Structure (VESS) for 0-250 mm depth and; Double Spade (DS) for 250-400 mm depth. Soil bulk density, shear vane and cone penetrometer readings were also taken. The impact of zone on soil structure was influenced by soil texture. The two outermost headland zones had poorer soil structure than the transition and in-field zones. The turning headland zone tended to have the poorest soil structural scores while the in-field zone had the best soil structural quality, highlighting the impact of machinery traffic. The results also showed that visual soil quality indicators are more sensitive than quantitative soil measurements, particularly at 250-400 mm soil depth.

Simulating breeding scenarios for faba beans

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AlphaSim is a flexible software package built in R which enables breeders to design various breeding schemes by simulating multiple aspects of a breeding program. In our case, AlphaSim is used to explore different breeding parameters for faba beans and gives the opportunity for more efficient and less costly selection cycles. A recurrent selection scheme was simulated in which the genetic architecture of the target trait (yield) was determined by 5 QTLs/chromosome with 300 segregating sites per chromosome. 18 scenarios involving different combinations of population size, selection intensity (SI) and outcrossing rate were tested for 30 selection cycles. Genetic gain (GG) and genic variation (GV) were compared across the tested scenarios. As expected, by not introducing new germplasm during the cycles genetic gain and genic variation are almost inversely related. Higher SI gives faster rates of GG during the first generations, however, possibly prematurely curtails genetic diversity needed to sustain GG in the long term. The smaller the population size, the greater the GG during the first generations but increasing population size is an inefficient means to increase long-term GG. Low rates of outcrossing favour rapid GG in the short term but limit long-term progress. The insight offered by these simulations provides a framework for rational design of small-scale breeding programmes.

Using N$_2$O isotopomers to explore N cycling and N$_2$O emissions in multispecies swards

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Soil N$_2$O emissions need to be reduced to improve the sustainability of grassland agriculture. The dominant N$_2$O production pathways can be explored using N$_2$O isotopomers (Site Preference: $\delta^{15}N^{\alpha}$ - $\delta^{15}N^{\beta}$). A short-term field experiment was carried out to determine the effects of multispecies swards on N$_2$O emissions and N cycling under contrasting soil moisture conditions, favouring either nitrification or denitrification. Perennial Ryegrass, White Clover and Ribwort Plantain at varying ratios made up the 8 different mixtures in a restricted simplex-centroid design. A 2% ^{15}N labelled urea application was made at a rate of 40 kg N ha^{-1}. N$_2$O sampling for flux and isotopomer measurements was carried out along with periodic soil sampling for KCl-extractable total oxidiseable N (TON) and NH$_4^+$. Under a uniform N application rate, modelled cumulative N$_2$O emissions significantly increased as proportions of White Clover increased, particularly under wet soil conditions. TON concentrations reduced significantly over time and there was a significant diversity effect of Perennial Ryegrass and Ribwort Plantain. NH$_4^+$ concentrations did not significantly change over time and there was a significant White Clover and Ribwort Plantain diversity effect. Results indicate that denitrification was likely the most dominant N$_2$O production pathway under wet soil conditions and that Ribwort Plantain was inhibiting nitrification. N$_2$O isotopomer results support this hypothesis as there was a significant interaction of White Clover and Ribwort Plantain and soil moisture for Site Preference values. These results emphasise that reduced fertiliser N is needed for swards containing White Clover to lower N$_2$O emissions and also suggest that Ribwort Plantain grown in multispecies swards could be a suitable biological strategy to inhibit nitrification which may help reduce N loss to the environment either as N$_2$O or nitrate leaching.

Developing a roadmap for sustainable and functional seed potato supply system in Eritrea

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Potato is a cash crop for growers and a high nutritional value food crop for consumers in Eritrea. However, the productivity (13t/ha) and production (35,000tonnes/year) is very low to meet the high demand. Inadequate supply of high quality seed potato is the core problem contributing to low productivity. The challenges are a combination of policy, institutional, technical, economic and social factors. Therefore, this PhD thesis has been developed to examine the Eritrean seed potato system and understand where the most critical weakness's lie and to propose a road map to identify bottlenecks and propose improvement options. The study focused on three areas: development of an appropriate procedure for potato variety flow in the country and examination, documentation and analysis of both the institutional and economic gaps in the Eritrean seed potato supply system: The research approaches used include seed potato stakeholder interviews, focus group discussions with potato farmers and local experts, local market assessments, a stakeholder potato variety preference survey, a case study on farm costs and returns, consultation with foreign experts and a review of 20 years of potato variety introductions to Eritrea. Also secondary data has been reviewed from Ministry of Agriculture reports. Overall, stakeholders preferred early maturing, diseases resistant, white skinned and easily cooked potato varieties. In the potato variety flow analysis, the top improvement options suggested are strengthening research institutions to create international networks for potato variety sourcing, strengthening local regulatory institutions to set and implement release and registration standards, engage potato farmers in the variety evaluation process, conduct variety trials in multiple -locations and the establishment of a potato variety collection for local use. At institutional level: encouragement of privatization in the seed value chain, empowerment of the regulatory service and research staff to manage seed quality assurance and seed production through tissue culture respectively.

A study on lodging in oats

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Lodging is a phenomenon in which plants are displaced permanently from their vertical position due to adverse weather conditions (strong winds and high-intensity rainfall), and can cause a substantial loss to the farmer. Lodging can either occur as buckling in the stem (stem lodging) or as a failure in the anchorage system (root lodging). Due to the complexity of the phenomenon, it is essential to understand the dynamic motion of plants as a result of their interaction with the wind and also to study the effect of different husbandry practices on the crop attributes associated with lodging. This research uses an analytical model which integrates various agronomic, biological and meteorological parameters in order to understand and replicate the lodging process. Field experiments were undertaken to provide a database of parameters which could be used to calibrate the model. Results show the drag area is the most influential parameter for both stem and root lodging. In addition, stem yield stress and the number of stems per plant were found to be important for stem lodging, whereas the root diameter was found to play a major role in root lodging. Interestingly, it was shown that visual parameters such as the natural frequency and the height of the center of gravity are less influential for both stem and root lodging.

Arable margins: Source or solution to crop pests?

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Arable margins are herbaceous strips surrounding arable fields that are managed for environmental purposes. Such margins support natural enemies including parasitoid wasps and ground beetles. Margins remain in place overwinter, thus there are concerns that they act as a green-bridge, facilitating the transfer of pests and diseases in successive crops. One such pest, the grain aphid (*Sitobion avenae*), is economically damaging to cereal crops, spreading Barley Yellow Dwarf virus (BYDV), and feeding on the grains.

Little is known about the interactions between aphid pests and their natural enemies in arable field margins, and subsequent impact to crop yield. To shed some light on this, I assessed BYDV infection, in fields with and without arable margins. I also ran an experimental trial with different mixes of grasses and wildflowers compared with a cropped control and assessed the adjacent crop to these plots for BYDV infection.

No evidence from this study suggests that arable margins increase BYDV in the adjacent crop. There is also no evidence that different mixtures of plants within margins have differing effects on BYDV levels in adjacent crops. Increasing our knowledge on how beneficial insects and aphids interact will help us answer why effects were not evident, as well as develop integrated pest management prescriptions, including field margins, mitigating economic damage caused by aphids.

Characterising powdery mildew resistance in oats

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Blumeria graminis f.sp. *avenae*, the causal agent of powdery mildew disease, is one of the most important diseases of oat production. Identifying resistant oat lines could be used to improve levels of resistance to powdery mildew. Eight commercial oat cultivars were scored in the field and in the glasshouse for powdery mildew infection at different growth stages. The results suggest that four commercial cultivars are susceptible to powdery mildew, while the other four cultivars have near-complete resistance to the fungus in the field in Ireland. Microscopic assessment of attempted powdery mildew infection showed a reduction in fungal growth on resistant cultivars was conferred by response typical of major *R-gene*, such as cell death and haustorial encasements.

Twenty-two Irish heritage lines have also been screened for powdery mildew susceptibility under glasshouse conditions. Two lines were identified as resistant at a seedling stage, with cell death and encasement responses conferring resistance. A high percent of papillae formation, which is a marker for penetration resistance, was also found in another of these heritage lines. Six lines from this oat collection were also found to express durable adult plant resistance. These lines will be analysed at both seedling and adult stages to characterise the differences in responses to fungal attack between growth stages.

Using barley and wheat sequences, an oat *MLO* gene candidate has also been identified. VIGS will be used to functionally characterise this candidate.

Mitigation of ammonia and greenhouse gases from slurry storage

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Slurry storage is a significant source of greenhouse gas (GHG) methane (CH_4) and ammonia (NH_3) in agriculture. Acidification has been shown to significantly reduce these emissions, however little work has been done on alternative slurry acidifiers. The aim of this project was to identify conventional and alternative slurry amendments that are safe and suitable to simultaneously mitigate GHG and NH_3 emissions during winter slurry storage. A series of incubation experiments were carried out in Teagasc, Johnstown Castle, simulating winter storage conditions. The following groups of acidifiers were investigated; 1) conventional chemical acidifiers, 2) acidification using waste products such as sugarbeet molasses, apple pulp, brewers grain, maize effluent, silage effluent, dairy processing waste and dairy washings at differing inoculation rates and 3) acidification using commercially available products. The chemical acidifiers: ferric chloride, sulphuric acid, alum and acetic acid were extremely effective at abating emissions, with NH_3 reduced by 96%, 85%, 82% and 73%, respectively, while ferric chloride, alum, sulphuric acid and acetic acid reduced CH_4 emissions by 98%, 96%, 95% and 94%, respectively. Waste products also abated emissions, with NH_3 reduced by, 67%, 50%, 40%, 36%, 25%, 17%, and 15% by sugarbeet molasses, apple pulp, brewers grain, maize effluent, silage effluent, dairy processing waste and dairy washings, respectively. However, significant abatement of CH_4 was only achieved using grass silage (reduction of 50%). Commercially available products relied mostly on microbial mode of action, with one product being Alum based. None of the tested commercial products significantly reduced in NH_3 or CH_4 production compared to control. Best performing products (ferric chloride, sulphuric acid and sugar beet molasses) from these incubation trials were selected for further investigation in a pilot-scale slurry storage facility followed by landspreading phase. This work is currently on going.

Drone imagery to map nitrogen input to improve nitrous oxide emissions estimation

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In grazing livestock systems, the deposition of reactive nitrogen via urination and dung are hotspots of environmental degradation (e.g. nitrate leaching), productivity limitations (e.g. reduction of grass production, over-use of fertiliser) and greenhouse gas emissions (e.g. nitrous oxide (N_2O) and ammonia emissions) which can account for 50 % to 60 % of the nitrogen input. These deposits occur randomly in the field, resulting in high spatial variability which prevents accurate accounting of their contribution to various pathways of nitrogen losses. This study presents a yearlong N_2O emissions map from an Irish intensively managed grassland grazed periodically by a dairy herd. The excreta deposition mapping was undertaken using high-resolution RGB images captured with a remotely piloted aircraft system combined with N_2O emissions measurements using closed statics chambers. The annual N_2O emissions were estimated to be 4.19 ± 0.40 kg N_2O-N ha^{-1} after a total N applied from fertiliser and excreta N of 1071± 84 kg N. The spatial distribution and size of excreta deposits was non-uniform, and on average for each grazing periods, 19.2 % of the field was covered by urine patches and 1.1 % by dung deposits. Locating deposition excreta in a low-cost manner opened an opportunity for a better spatial modelling of nitrogen inputs, allowing better targeting of nitrogen fertilisers and the estimation of greenhouse gas emissions.

Mid-infrared spectroscopy as an alternative to laboratory extraction for the determination of lime requirement in tillage soils

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Lime is a crucial soil conditioner to bring agricultural soils to optimum pH values for nutrient availability. Lime recommendations are typically determined in laboratory extractions, the most common being the "Shoemaker-McLean and Pratt" (SMP) buffer method, that requires carcinogenic reagents soon to be abolished under the EU legislation. As an alternative to wet chemistry, mid-infrared (MIR) spectroscopy has shown to be a cost-and time effective method at predicting soil properties. The capability and feasibility of diffuse reflectance infrared spectroscopy (DRIFTS) to predict lime requirement (LR) in tillage fields is examined. Samples from 41 cereal tillage fields (n=655) are used to build a calibration for DRIFTS using partial least squares regression (PLSR). The samples were split into calibration set (31 fields, n=495) and validation set (10 fields, n= 160). After pre-processing with trim, smoothing and standard normal variate, a calibration model using 6 latent variables, provided R^2 of 0.89 and root mean square error of cross-validation (RMSECV) of 1.56 t/ha. Prediction of all fields from the validation set resulted in R^2 of 0.76 and root mean square error of prediction (RMSEP) of 1.68 t/ha. The predictions of the single fields ranged from R^2 values of 0.41 to 0.72, RMSEP of 0.48 to 4.2 t/ha and ratios of performance to inter-quartile distance (RPIQ) of 0.45 to 3.56. It was shown that the signals of soil constituents having an influence on the LR were picked up in the spectra and were identified in the loading weights of the PLSR. While the error is too high to predict the variability of LR within the field, MIR prediction using field averages provided a viable alternative to current laboratory methods for blanket spreading of lime on tillage fields.

Evaluation of *in situ* production of mannitol in dairy fermentations

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This study aims to investigate *in situ* production of mannitol for potential use in dairy fermentations. Mannitol is a six-carbon polyol, sugar alcohol, used widely in the pharmaceutical industry and as a food additive due to its sweet taste and cooling effect. Mannitol is 50-70% as sweet as sucrose with less than half the calories. Polyols have two EFSA approved health claims; reduction of the glycaemic response and protection against tooth decay. Despite its wide use as an additive, little is known about its production *in situ* in fermented foods. 261 lactic acid bacteria were isolated from raw milk and screened for mannitol production using HPLC. Isolates were grown in sugar supplemented media before HPLC analysis; from this 29 strains were identified for further study. To optimise production multiple sugar combinations were tested, as fructose and/or glucose is required for mannitol production, and *Weisella paramesenteroides* LL-677 was selected. In broth supplemented with fructose/glucose, 23.48g/L of mannitol was detected after 16hrs. The results from the initial studies in broth were applied in skim milk fermentations, acidification to pH4 occurs over the first 24hrs.LL-677 is now being applied in milk fermentations where pH, mannitol production, and sugar concentrations are being monitored over time. This initial study shows LL-677 is a high mannitol producer, and warrants further study for production of a low-calorific, sweetened fermented milk product.

Actifensins are a novel class of bacteriocins homologous to eukaryotic defensins

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Bacteriocins are small ribosomally synthesised antimicrobial peptides which can have a narrow or broad spectrum of inhibition. They are natural by-products of fermentation and microbial production can be considered a probiotic trait. In a screen for food grade bacteriocin producing lactic acid bacteria an *Actinomyces ruminicola* isolate was found with potent broad spectrum antimicrobial activity. MALDI-TOF MS, N-terminal amino acid sequencing and genome sequencing were used to identify the bacteriocin and its gene which were previously undescribed. The bacteriocin was purified and found to have a mass of 4091+/-1 Da with a sequence of GFGCNLITSNPYQCSNHCKSVGYRGGYCKLRTVCTCY containing 3 disulphide bridges. Surprisingly, near relatives of actifensin were found to be a series of related eukaryotic defensins displaying greater than 50% identity to the bacteriocin. Subsequent pan-genome analysis identified 47 coding sequences for homologous peptides within 161 *Actinomyces* genomes, and one within a *Corynebacterium* sp. These peptides displayed a remarkable level of diversity with a mean amino acid identity of only 52% between strains/species. This level of redundancy suggests that this new class of bacteriocins may provide a very broad structural basis on which to deliver and design new broad-spectrum antimicrobials.

Selection of rosemary and thyme by-products as natural antioxidants for dairy products

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Irish agri-food sector generates millions of tonnes of polyphenol-rich herbal by-products, which can serve as sources of natural antioxidants in food products including dairy. Hence, the antioxidant activities of 80% methanolic extracts of various herbal by-products in Ireland were initially assessed spectrophotometrically (TPC, DPPH, FRAP), while factors including morphological parts (leaves, stems), geographical variation and recovery with food grade solvents (80% ethanol, water) were also investigated. Using Relative Antioxidant Capacity Index (RACI), rosemary and thyme were selected for application as food ingredients; however, the exploitation of their extracts in dairy was impeded due to their high chlorophyll content, which also interferes the chromatographic analysis of their polyphenols. Therefore, the impact of dechlorophyllization techniques (*n*-hexane/water partition, activated charcoal bleaching and ChloroFiltr® decolourization) on the potent polyphenols of their 80% ethanolic extracts was assessed through chromatography-mass spectrometry analyses and spectrophotometric based assays (FRAP, DPPH, ABTS). As it was revealed, activated-charcoal bleaching and ChloroFiltr® decolourization effectively removed chlorophyll *a* and *b*, whereas traces (<0.05 ppm) were detected after *n*-hexane: water partitioning. Thyme dechlorophyllized extracts prepared using activated-charcoal and ChloroFiltr® had the lowest RACI, while rosemary extracts had positive RACI values following the same treatment. Chromatographic analyses indicated that phenolic diterpenes (carnosol and carnosic acid), as well as rosmarinic acid in general, had not been significantly decreased ($p>0.05$) after activated-charcoal treatment, while *n*-hexane treatment maintained the major flavonoids and phenolic acids with non-significant ($p>0.05$) losses in most cases.

Presence and survival of bacterial pathogens during anaerobic digestion and in digestate on farmland

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Concerns about pathogenic bacteria in anaerobic digestion (AD) feed materials, survival during the fermentation process and contamination of farmland on which digestate is spread are inhibiting the development of AD green energy production. The objectives of this study were; [1] to test AD feed materials for *Salmonella* spp., *Listeria monocytogenes*, *Escherichia coli* O157, *Enterococcus faecalis* and *Clostridium* spp.; [2] to investigate their survival during the AD process and [3] to compare pathogen survival and leaching into soil when applied to farmland in digestate versus slurry. AD feed materials and digestate were tested for the target pathogens using standard microbiological methods. Model fermentation (30ml and 10 litre) systems were developed and used to test survival during the AD process using commercial recipes and conditions. In collaboration with Teagasc-Johnstown Castle, survival and leaching of each pathogen was tested using field trials. Our results show that AD feed materials and digestate were contaminated with *Salmonella* spp., *L. monocytogenes*, *E. coli* O157, *E. faecalis* and *Clostridium* spp. T_{90}-values (time required to kill 90% of bacteria) were 0.6 – 2.3 , 3.1 – 23.5, 2.4 – 2.8, 2.2 – 4.5 and 2.4 – 7.4 days, respectively, suggesting survival during AD fermentation was possible. Field trials showed that survival and leaching from digestate was lower than in slurry. It was concluded that AD feed materials may be contaminated with bacterial pathogens, which can survive the AD fermentation and if applied to land will survive and leach into the soil (albeit at a lower rate than if applied in slurry) necessitating thermal treatment of digestate before land application.

Generation of sinapinic acid-containing extracts from Irish rapeseed meal and characterisation of their bioactive properties for potential human health applications

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Rapeseed (*Brassica napus L.*) contains more phenolic compounds than any other oilseed plant, and the production of rapeseed oil results in a low-economic value by-product called rapeseed meal that includes the phenolic sinapinic acid (SA). Sinapinic acid constitutes 70-90% of the esterified phenolic acids in rapeseed meal and has known bioactive properties including anti-diabetic, anti-cancer and anti-inflammatory activities. Isolation of SA from rapeseed meal fits with the current concept of a circular bio-economy and total utilisation of crop harvest. Phenolic extracts containing SA were prepared from Irish rapeseed meal (kindly supplied by Donegal Rapeseed Oil) by solvent extraction with methanol: acetone: water (7:7:6, v: v: v). Extract 1 contained 0.053 mg/mL SA (5.3% w: v). The methodology was modified to produce extract II, with an increased SA content of 0.569 mg/mL (57% w: v). The toxicity profile of both extracts and commercial SA were determined using cell and the resazurin viability assays. Based on these results the non-toxic dose was determined as ≤ 0.5 mg/mL for both extracts and ≤ 2.2 mM for commercial SA. The benefits of the extracts on heart health were determined using the Angiotensin Converting Enzyme-I (ACE-I) inhibition assay. SA extracts I and II inhibited ACE-I by > 90%, values similar to known inhibitors of ACE-I such as Captopril. Chronic inflammation is known to play a role in the underlying pathology of various diseases including cardiovascular disease, diabetes, arthritis and celiac disease. The THP-1 cell line and human-derived peripheral blood mononuclear cells were used to examine the potential anti-inflammatory activities of the extracts. The extracts were found to significantly reduce the LPS-induced expression of TNFα, IL-6, and IL-12 in human PBMCs.

This work highlights the potential of SA-containing extracts as functional food ingredients to promote human health and prevent diseases.

Dynamic *in situ* imaging of semi-hard cheese microstructure under large-strain tensile deformation: Understanding structure-fracture relationships

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Knowledge of the breakdown behaviour of cheese is important for gaining insights into texture perception, flavour and nutrient release, as well as the origin of undesirable texture defects within the cheese matrix such as slits and cracks. In this study, changes in the microstructure of semi-hard cheeses were observed *in situ* under tensile deformation by placing a microtensile stage directly under a confocal scanning laser microscope (CSLM), and recording force/displacement data simultaneously. A small indentation (called a notch) was made at a centre point on the test specimens, and growth of the notch was observed under tensile deformation using CSLM. On tensile deformation, detachment of fat globules and their subsequent release from the cheese matrix were observed, suggesting that they are weakly bonded to or entrapped within the cheese matrix. Moreover, an inherent micro-defect was observed at a curd granule junction within the cheese matrix, which fractured along the curd granule junction under tensile deformation, suggesting that such micro-defects could be a key to the formation of undesirable slits or cracks. Furthermore, the fracture behaviour of semi-hard cheese varied with ripening temperature, coagulant type, and inhibition of residual chymosin activity. Overall, this study demonstrated the potential of dynamic *in situ* imaging of cheese microstructure for developing a greater understanding of the breakdown behaviour of cheese matrices.

Polyphenols from brewer's spent grains and their anti-cholinesterase activities

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Alzheimer's disease (AD) is the main cause of dementia affecting ~50 million people worldwide. Inhibition of cholinesterases has been the target in treating AD. Several phytochemicals including polyphenols have been assessed for anti-cholinesterase activity. In this study, bioprospection of polyphenol-rich brewers' spent grain (BSG) as potential cholineasterase inhibitors has been assessed.

To generate polyphenol-rich BSG extracts, characterise and quantify the polyphenols and evaluate their anti-cholinesterase activities.

BSG polyphenol extracts were generated using 60% acetone and 0.75% NaOH solutions. Further fractions of BSG extracts were achieved through liquid-liquid partitioning using various organic solvents. Polyphenols were analysed by colourimetric and LC-MS/MS methods. The inhibition of acetyl- and butyryl-cholinesterase activity was determined by Elman's method.

Saponified BSG yielded higher polyphenols than the acetone extracts, i.e. 19.2±0.4 vs 3.85±1.89mg GAE/g dw. However, the ethyl acetate-partitioned fractions had the highest polyphenol content (4.71 mg GAE/g dw). Total polyphenols by LC-MS/MS showed 1.16±0.09, 0.03±0.002 and 2.23±0.09 mg/g BSG dw for acetone, saponified and ethyl acetate fractions, respectively. The best inhibitions of acetyl (34.4%) and butyryl (30.2%) cholinesterase activities were shown by the acetone extract, which contained catechin constituting ~55% of the total polyphenols. Authentic catechin at 1mg/mL showed similar inhibitions, 20.2% (acetylcholinesterase) and 32.8% (butyrylcholinesterase). Blend of polyphenols reflecting their concentrations in the acetone extract at 1mg/mL also showed similar anticholinesterase inhibitions (19.0% and 29.6%, respectively).

The results showed that the polyphenol-rich BSG extracts, with catechin as key polyphenol, have the potentials as natural agents for cholineastease inhibitors.

Assessment of the prebiotic potential of dietary fibres and lipid sources to promote diversity of diabetic human gut microbiota in vitro

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Obesity is a global health concern and increases the risk of a number of inflammatory associated diseases. The gut microbiota (GM) may play a major role in the progression of such diseases. GM diversity and microbiota-derived metabolites can modulate immune function and inflammation, and loss of diversity has been observed in type 2 diabetic patients. Specific food ingredients can promote gut microbiota diversity and in turn promote health and well-being. The objective of this study was to identify dietary fibres and lipids that can promote GM diversity and short-chain fatty acid (SCFA) production in obese diabetic people. Dietary fibres (oat fibre and yeast beta-glucan) underwent a simulated digestion to replicate how they would reach the large intestine. Faecal samples were collected from obese, diabetic patients and subjected to 24hr pH controlled anaerobic faecal fermentation experiments supplemented with combinations of the pre-digested fibres and lipid sources. Inulin and glucose served as positive and negative controls respectively. Effects on GM composition were assessed by 16S sequencing and SCFA production was assessed by gas chromatography. The results from this study show that dietary fibres in combination with fish oil can increase diversity of the GM obtained from obese diabetic patients in vitro compared with no lipid. Conversely, oleic acid (with fibres) reduced diversity whereas palmitic acid (with fibres) significantly decreased SCFA concentrations compared with no lipid. Dietary fibres and fish oil have the potential to promote health in obese diabetic patients by increasing the diversity of the GM. Palmitic acid significantly decreases SCFAs and this effect may contribute to its known pro-inflammatory effect.

A systems-wide analysis of key metabolic pathways demonstrates the flavour-forming ability of the Gram-positive bacterium *Macrococcus caseolyticus*

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Macrococcus caseolyticus a Gram-positive, commensal organism documented to be present as a component of the secondary microflora in fermented foods such as Ragusano, Fontina cheese and Cantonese sausage where the organism appears to play a role in ripening and the development of the final organoleptic qualities. The objective of this study was to investigate metabolic pathways involved in flavour compound formation of *M. caseolyticus* species predicted from enzymatic assays, whole genome sequencing and metabolomics data generated by Gas chromatography-mass spectrometry performed on five *M. caseolyticus* strains (isolated from diverse sources including whale skin, bovine milk and Irish cheese samples). Enzyme activities of the proteolytic and lipolytic cascade including cell-envelope proteinase, peptidases, esterases, lipases, aminotransferases and glutamate-dehydrogenase indicated strain– to strain variation. All except ATCC51835 demonstrated high cell wall-bound proteinase activity, and Reversed-phase high-performance liquid chromatography profiles generated confirmed the extensive hydrolysis of milk proteins induced by CEP. GC-MS analysis of the volatile compounds produced when these cultures were grown in lactose-free milk demonstrated distinct volatile profiles. This information was coupled with WGS data identifying the distribution of components of the proteolytic and lipolytic system in these strains, confirming their genetic and metabolic diversity. This research, to date, has identified membrane-bound proteases in *M. caseolyticus* deriving extensive casein hydrolysis, which may be harnessed to produce greater and diverse flavour compounds.

Participatory agri-environmental governance and integrating multi-actor knowledge: a case study from Ireland's EIP Initiative

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Recent trends in European agricultural governance have sought to increase collaboration between government institutions, farmers, and other relevant stakeholders. The conviction that a range of different knowledges are required to produce spatially adapted policy implementation underpins these trends. However, research of how such collaboration unfolds in practice is scarce. Ireland's European Innovation Partnership (EIP) Initiative offers a valuable opportunity to help address this gap in the literature. Accordingly, this PhD research has interrogated collaborative practice in Ireland's EIP Initiative, and the capacity for such practice to incorporate a range of knowledges.

Ireland's EIP Initiative called on multi-actor groups to form and propose projects that could improve the environmental sustainability of Irish agriculture. This PhD research involved conducting a qualitative in-depth case-study of the project proposal development process undertaken by one such group in Ireland's Western uplands. The results of this research show that a range of actors including farmers, scientists, and rural development professionals collaborated on the proposal. Moreover, different knowledges were merged, particularly in the process of agreeing upon spatial boundaries. However, the process also relied upon context specific decision-making structures. Collaborative approaches to governance *can* incorporate a range of different knowledges. Yet utilising these approaches to produce spatially adapted policy implementation must account for the flexibility and labour involved in attending to context specific socio-historical relationships.

Safer farming behaviour associated with safety engagement in dairy discussion groups

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Farming is a dangerous sector to work in, worldwide. Despite regulatory and educational efforts to promote safety and health risk management, agriculture lags behind other high-risk sectors, e.g. construction, with fatal consequences. Research suggests that group-based social learning can stimulate adoption of safe, health-protective work behaviours. It is not clear if this approach could be effective among existing farmer knowledge-sharing groups, e.g. dairy discussion groups (DDGs).

To evaluate the influence of a DDG-based safety engagement intervention on safety behaviours.

The intervention, comprising two trial approaches (A and B) and a control group, was implemented among 84 cluster-randomised DDGs, involving 1220 farmers. Pre-trial and post-trial surveys collected information about the frequency with which farmers implemented, and intended to implement, eight safety behaviours. Paired two-sided *t*-tests evaluated the difference between surveys.

Of the 642 farmers who completed surveys, 145 completed both pre-trial and post-trial surveys (A = 52, B = 57, control = 36). A statistically significant positive change in behaviour intention occurred among farmers in trial approach A, and in behaviour implementation among farmers in trial approach B ($p < 0.05$).

This research indicates that DDGs can effectively stimulate adoption of safe farming behaviours. This finding is of relevance for other aspects of total farm sustainability that are influenced by individual behaviour, e.g. environmental management practices.

Towards an Automated System for Intelligent Screening Grey Literature

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Grey Literature refers to information produced on all levels of government, academics, business and industry in print and electronic formats, such as blogs, news articles Wikipedia pages. Grey literatures, sometimes, reveal interesting and useful information which benefit people in academic or industry area. However, screening grey literature for identifying the potentially related ones is a time-consuming work. Hence, we proposed an approach that aims to reduce the manual effort in the screening procedure, as well as correctly identify the potentially excluded/included grey literature for further review.

We reframe this as a text labelling task, and we develop an active learning framework which is able to predict the label of each document.

Combining active learning and BERT text representation, to generate a model which can automatically classify the documents. The active learning framework ensures that an oracle only need to review a few articles and BERT, a text representation technique, has greatly increases the accuracy of the model.

We presented an evaluation experiment which explored the effectiveness of BERT in an active learning context. The result showed that, BERT combined can achieve high accuracy at the very early stage which means fewer documents reviewed. Concretely, the results show that the proposed system can save nearly 80% workload at most while maintaining a high accuracy.

We suggest that BERT with uncertainty sampling is the default framework for text labelling tasks and hence, can be generalized to label the grey literature dataset.