Proposed Research Programme to Increase Profitability and Sustainability of Irish Dairy Farms

Financed by Dairy Research Trust 2017-2021

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Background

- The prospects for the Irish dairy sector in the medium to long term are positive. This is based on significant growth in demand for dairy products worldwide, especially in developing countries.
- The family farm model of milk production has served Ireland well; the sustainability of this model will be dependent on maintaining a good standard of living for the capital and labour employed.
- An increased number of young highly trained dairy farmers and skilled dairy farm operatives will be required.
- Milk price volatility will continue to be a feature of dairy markets. This price volatility is driven by relatively small changes in supply-demand balance; only ~7% of milk produced globally is traded.
- Higher quality milk will be required for the production of higher value-added products, including infant formula; this will required dairy herds of high health status.
- There will be an on-going requirement to reduce the environmental footprint of milk production. This will include reduced nutrient loss to ground water (N and P), increased carbon efficiency and improved biodiversity.

Vision for the Irish Dairy Industry

The Teagasc research programme funded under the Dairy Research Trust is consistent with the vision for the Irish Dairy Industry outlined in the DAFM FoodWise 2025 report. Through Dairy Research Trust funding, Teagasc proposes to accelerate the growth and improve the efficiency of the dairy sector. This will require efficient utilisation of the collective industry investment in research, extension and development, while also working with industry stakeholders to develop and encourage innovation for the future of the sector. Teagasc is committed to developing an innovative and vibrant Irish dairy industry, which is economically prosperous and fulfilling for all stakeholders and is founded on responsible environmental management. The following points summarize the Teagasc vision for the Irish dairy industry:

- high profit pasture-based milk production systems that provide stable competitive returns to Irish dairy farmers. These systems must be capable of supporting existing family farm business expansion, while providing attractive investment opportunities for new industry participants.
- an internationally competitive, innovative and sustainable dairy sector that achieves growth of 5% per annum, and contributes to national economic prosperity through job creation and increased dairy product exports.
- industry practices that deliver the highest standards of product quality to facilitate development of a diverse product portfolio that generates the highest international value per kg of milk produced from pasture.
- sustainable production practices in terms of animals, employees, customers and the environment.
- provision of the highest international standards of R&D services and innovation.

Economic benefits of the current and future Dairy Research Trust Programme

The overall objective of the Dairy Research Trust Programme is to increase the profitability of dairy farming in a manner that promotes excellent food quality and safety, while complying with environmental and animal welfare requirements. An estimate of the contribution of technology application to farm productivity between 2011 and 2015 and projected improvements to 2021 is summarized in Table 1.

Table 1. Technical and financial performance for manufacturing milk producing herds in Ireland based on performance in 2011 and 2015[1] plus projected performance in 2021

	Sectorial Average		
	2011	**2015**	**Expected performance in 2021**
Milk sold (l/cow)	4,841	4,938	5,242
Milk solids (kg fat plus protein)	360	383	418
Protein and fat %	3.37/3.89	3.50/4.03	3.56/4.19
Calving interval (days)	403	392	386
Mean calving date	8th March	3rd March	26th February
Land (ha)	57.3	58.3	59.3
Stock Rate (LU/ha)	1.84	1.95	1.98
Dairy cows per farm (number)	66	70	91
Herd EBI (€)	99(28)	140 (69)	200 (129)
Dairy AI entering herd (%)	51	52	54
SCC (‘000)	252	181	170
6-Week Calving Rate (%)	52	57	62
LU/labour unit (number)	63	68	73
Replacement rate (%)	19.7	23.5	22
Herbage utilised (kg DM/ha)	7,485	8,279	9,041
GHG (kg CO2E/kgMS)	14.8	14.2	13.5
Nitrogen efficiency (%)	24.2	26.2	26.0
Concentrate per cow (kg)	875	936	900
Nitrogen (kg/ha)	168	175	195
[2]Margin @ 28c/l (€/kgMS)	2.96 (0.40)	4.90 (0.63)	8.72 (1.10)
[2]Net margin (€/hectare)	264	472	905

[1] The current Dairy Research Trust Programme ran from 2011 to 2016 inclusive. Data from 2016 was not included as it was not available at the time of writing. **[2]** Full labour costs are included in all analysis.

The technical and financial performance for manufacturing herds was calculated based on the Teagasc National Farm Survey data. Full labour costs are included in the financial analysis (~€25,000); it excludes all direct payments and the base milk price (3.6% fat and 3.3% protein) used is 28 cent per litre.

Table 1 show that the increase in technical performance at farm level nationally between 2011 and 2015 is equivalent to an increase in profitability of €7,386 per dairy farm in 2015 compared to 2011, or an increase of €1,846 per farm per year. Based on 16,500 dairy farmers this is equivalent to an increase of €30 million annually between 2011 and 2015.

Table 1 also shows that when 2021 is compared to 2015 there is a potential for a further annual increase of €69 million annually; the larger increase is based on an expanded dairy industry. It's important to note that all financial gains were calculated on a base milk price of 28 cent per litre.

Priority areas for research with the assistance of Dairy Research Trust Funding
In light of the vision for future milk production outlined above the following areas of the research programme will be strengthened:

- People in dairying
- Dairy cow genetics
- Dairy cow reproduction
- Grass breeding and evaluation
- Grazing management
- Milk production systems and environmental sustainability
- Winter/liquid milk production
- Milk quality
- Milking and energy efficiency
- Dairy cow nutrition and increasing added-value
- Milk production on heavy soils and the BMW regions
- Dairy cow health and welfare
- Technology Transfer/Dissemination of Research Results

People in Dairying

- The Dairy Research Trust identified an adequate supply of highly skilled young people entering dairy farming as the main treat to future sustainable expansion of the Irish dairy industry, especially in one person units.
- Dairy farms are becoming increasingly busy places to work. Milk quota abolition and farm expansion has led to an increased number of cows nationally (1.4 million in 2016 compared to 1.1 million in 2010) and per farm. Farmers must evaluate their current work practices, the labour efficiency of their farm facilities, their own role and the role of others in the business in order to make sure workloads remain sustainable.
- The increase in dairy farm scale has created many new full and part time positions within dairy farms. The Teagasc Stepping Stones to a Career in Dairy Farming booklet was produced to highlight these new employment positions and the skills required to successfully complete each position.
- Becoming an employer and working with short and long term hired non-family labour is one of the immediate challenges facing many farmers. The culture of employment on farms must be modernised to reflect the requirements of employees within modern labour markets. Dairy farmers must develop additional skills to manage non-family labour and achieve the best outcomes for the farm business.
- There is an increasing requirement for a variety of skills for successful dairy farming due to increased operational scale, a more volatile production environment, greater business opportunities and increased administrative burden on dairy farms. Responding to the recommendations of Food Harvest 2020, Teagasc in conjunction with UCD and other stakeholders created the Professional Diploma award in Dairy Farm Management (PDDFM) to provide the next generation of dairy farmers with

the additional skills and knowledge to meet the challenges of an expanding industry in the future.

- In order to attract and retain highly motivated and skilled people in Irish dairying, career progression opportunities need to be provided via collaborative farming opportunities (partnerships, share farming and leasing).

People in Dairying research programme 2017-2021

1. Dairy farming will be promoted as an attractive career choice, offering good status and pay, a high quality of life, and well-defined training and career paths.
2. The characteristics of a labour efficient one person unit dairy farm with a particular focus on the spring period will be established.
3. Develop new KPI's, farm management strategies and business structures to achieve sustainable workloads and to allow benchmarking between farms, including aspects of Health and Safety.
4. Complete a quantitative study to determine the people resources needed to satisfy the requirements of the expanding Irish dairy industry. This will be based on different potential levels of expansion over the next 5-10 years, and will quantify the number and type of potential positions required.
5. Develop farm business structures for young well trained farmers and land owners that incentivise maximum efficiency and provide returns to the different stakeholders involved.
6. Continue to evaluate and highlight the skills needed to successfully run a dairy farm business. Audit the prevalence of these skills across the industry, and determine how they are being developed and improved.
7. Qualitative research will be undertaken to better understand the social and cultural dynamics that influence collaborative farming uptake in dairying.
8. The next phase of the PDDFM programme will provide students and host farmers with additional training in people management to improve the culture of employment on dairy farms. A survey will be carried out to highlight the characteristics of resilient agricultural systems. This will be based on evidence of farm level initiatives to improve work efficiency, employer and employee satisfaction and increase the overall operational scale and efficiency of the farm business.
9. A focus group of PDDFM host farmers will be established to identify knowledge deficits in the programme and training needs of host farmers. The focus group will provide further depth and insight into the questions asked in the survey on the characteristics of resilient agricultural systems. A tailored training programme for PDDFM host farmers and students will be designed and developed using action based participatory research.
10. A longitudinal study of graduates from PDDFM and the Advanced Dairy Herd Management programmes will be undertaken to track their career development pathway and employment success.

Dairy Cow Genetics

- The proportion of Holstein-Friesian semen used from genomically tested sires is increasing almost linearly since its introduction in 2009; in 2015, 70% of Holstein-Friesian semen used in Irish dairy herds originated from young genomic test sires. The EBI is currently increasing by €10 per year.
- A cow-level ranking tool (Culling Index), complementary to the EBI, has been prototyped and released on a pilot basis. This decision support tool will aid farmers in the identification of cows for culling. This proven and validated tool is by far the most comprehensive available globally.
- Genomic selection is now commonplace in Ireland and internationally. Tools were also developed to maximise the benefit accruing from genotype information including parentage verification and assignment, monitoring of major genes and lethal mutations, and the quantification of breed composition. Teagasc and ICBF jointly developed the first ever national custom genotyping platform, resulting in the cost of genotyping dairy cattle in Ireland being amongst the lowest available globally.
- Results from the Next Generation Herd have clearly demonstrated the superior performance (especially the reproductive performance) of the elite EBI animals compared to that of the national average EBI contemporaries.

Dairy Cow Genetics research programme 2017-2021(in collaboration with ICBF)

1. Investigate the feasibility of including traits in relation to animal health, feed intake and efficiency plus detailed milk composition in the EBI index.
2. Research will be carried out to identify strategies to routinely procure relevant lameness data, define pertinent phenotypes, estimate genetic parameters, undertake genomic evaluations, and determine the relative weighting that should be placed on these traits within the EBI.
3. Develop a dairy cow selection index that ranks bulls on their potential carbon footprint effect. To test various genetic strains of animals to ascertain their overall effect on carbon footprint."
4. Genomic evaluations in Ireland are currently only available for Holstein-Friesian cattle. Presently, no country provides official across-breed genomic evaluations in dairy cattle. Research must be undertaken to quantify the feasibility of achieving high accuracy genomic predictions in Jersey (crossbred) animals. Moreover, implementation of the superior one-step genomic predictions must be researched with a view for deployment by the ICBF.
5. Research will continue on establishing and implementing the most sustainable national breeding program to achieve long-term gains, especially by exploiting (anticipated) advancements in genomic and reproductive technologies.

Dairy Cow Reproduction

- Excellent fertility will be necessary to reduce costs, maximise grass utilisation, and allow dairy replacements to be generated from the highest merit dams in the herd. Caving interval has reduced nationally from 403 days in 2011 to 389 days in 2016.
- In a non-quota scenario, an earlier mean calving date will be required to increase farm profitability, reduce peak milk supply and increase processing plant utilisation. Median calving date has moved from 9 of March in 2011 to 4th of March in 2015.
- Achieving a compact calving pattern requires high **submission** and satisfactory conception rates during a breeding season of fixed duration. Consequently,

reproduction research will focus on strategies to: (a) maximise submission rates; and (b) improve likelihood of pregnancy establishment after insemination.

Dairy Cow Reproduction research programme 2017-2021

1. Develop predictive tests for fertility in bulls used for artificial insemination, allowing low semen fertility bulls to be withheld from the marketplace.
2. Develop predictive tests that allow identification of bulls that have little or no reduction in fertility in sex-sorted semen. This would facilitate development of high fertility sexed semen, allowing replacements to be generated from the highest EBI dams, and more beef semen to be used on lower merit dams.
3. Moorepark has assembled the *Next Generation Herd* of dairy cows. This unique comparison of cows with national average EBI vs. cows within the top 1% of the national herd for EBI provides a powerful resource to improve our understanding of the underlying physiology of sub-fertility and nutrient partitioning in pasture-based systems. Basic research with these cows will allow identification of gene and gene networks that regulate reproductive performance, and to accelerate the rate of genetic gain for fertility traits.
4. Evaluate automated heat detection aids based on Activity Monitoring Systems for use on commercial dairy farms.

Grass Breeding and Evaluation

- Ireland has defined a grass breeding objective, the Pasture Profit Index. This allows grass breeders to focus breeding efforts towards delivering improved varieties for the Irish grassland industry.
- The Pasture Profit Index needs to be reviewed regularly to ensure that it is correctly focused on the commercial performance of grass varieties, especially variety lifetime performance. On-farm grass variety evaluation can now link grass breeding and evaluation to the challenges of commercial grassland farmers.
- Evaluation of animal performance when new grass varieties are fed is required. Therefore, more focus will be placed on key characteristics that influence animal performance under grazing conditions rather than under traditional evaluations based on cutting and conservation.
- Classical grass breeding has delivered DM yield increases of 0.5% per year over the last 40-years. Genomic selection has the potential to accelerate genetic improvement and reduce the time lines compared with conventional grass breeding by 5-8 years. Developing genomic selection methodologies will improve the productivity of a new generation of grass varieties for Irish production systems.

Grass Breeding and Evaluation research programme 2017-2021

1. In association with the Department of Agriculture, Food and the Marine, the Pasture Profit index will be refined further to incorporate new traits such as grazing-out intensity, long term dry matter production performance and dry matter yield stability using data from grass variety performance on commercial farms (including estimates of genotype by environment interaction).
2. A new approach to white clover evaluation (under both frequent cutting and grazing systems) is required to identify the best protocol that reflects performance in a rotational grass-based system of animal production.

3. Detailed grass physiology research will focus on understanding the effects of contrasting sward structure and composition, and the consequent impact on the animal performance at various periods during the grazing season.
4. Grass seed mixtures comprised of various cultivars (including monocultures) will be compared over a number of years for DM production, sward quality, re-heading period and persistency on commercial farms.
5. Genomic estimated breeding values will be incorporated into grass breeding programs, thereby accelerating genetic gain for traits that are pertinent in Irish grass-based milk production.

Grazing Management

- Spring-calving milk production systems are primarily based on pasture with some silage and concentrate supplements. The key strategy to improve farm productivity is to increase potential grass utilised to greater than 11.5 t DM/ha, which would facilitate an increase in milk output to greater than 1250 kg milk solids/ha. The over-arching goal is to ensure that any increases in milk output are primarily a result of increased grass utilised, improved pasture quality and higher sward energy density.
- Including white clover in N fertilised perennial ryegrass swards can increase herbage production and milk solids production by up to 13%. Additionally, reducing N fertiliser application to grass-clover swards in a high stocking rate system (2.74 LU/ha) will not result in reduced annual herbage production.
- PastureBase Ireland is a web-based grassland decision support tool. It was developed to support decisions related to optimal pasture production and utilization. Currently there are approximately 1,000 grassland farmers in Ireland using PastureBase Ireland (recording at least 30 farm grass cover measurements annually) to assist with weekly grazing management decisions.
- Using grass measurement to monitor farm grass supply has helped to improve pasture utilisation and increase cow production from pasture. Spring grazing management is optimised using the spring rotation planner; mid-season grazing management and dairy cow performance are optimised using the pasture wedge; and autumn grass budgeting is essential to make maximum use of autumn grass.
- During periods of sustained rainfall, and especially on farms with heavy soil types, on/off grazing can be used strategically to maintain grass intake during periods of difficult grazing conditions, reduced poaching damage and increase grass DM production.

Grazing Management research programme 2017-2021

1. Evaluate the impact of autumn and spring grazing management strategies at high stocking rates on pasture production and utilisation, sward quality and animal intake and performance.
2. Evaluate the potential to improve sward and animal productivity through incorporation of white clover into grass swards. A major focus of this work will be to benchmark the lifetime DM production performance of such swards.
3. Evaluate the impact of alternative feed budget management strategies on animal and sward performance, grazing season length and grass utilisation within higher stocking rate grazing systems.

4. Incorporate a grass growth prediction model using meteorological data into PastureBase Ireland to form a new decision support tool. This will allow farmers to more accurately budget feed supply, and make strategic grassland management decisions specific to their farm.
5. Develop and refine new decision support tools in PastureBase Ireland for grazing management by combining existing best practice with up to date research information with particular focus on the spring and autumn periods.
6. Benchmark new grazing management targets for stocking rates, soil types and climatic zones in Ireland.
7. Assess N leaching on vulnerable soil types used for intensive grass-based dairy production systems to provide scientific data for Ireland's derogation from the 170 kg N/ha stocking limit of the EU Nitrates Directive.

Milk production systems and environmental sustainability

- In the medium term, the outlook for international dairy product prices are good, but volatile; therefore dairy farm businesses should move to control their own future by developing farming systems insulated from market volatility and external cost exposures.
- There will be an ongoing requirement to reduce the environmental impact of dairy farming on the environment; this will require a reduced carbon foot print of Irish milk as well as reduced losses of N and P to water.
- The new major limitations on dairy farms will be access to land contiguous to the milking parlour to graze cows and availability of skilled labour, particularly during the spring calving period.
- Integrated modelling of dairy production systems will be required to provide insight into the possible consequences of changes in farm production technology, environmental regulations and industry milk pricing strategy on farm profitability and sustainability.

Milk production systems and environmental sustainability research programme 2017-2021

1. Quantify optimum stocking rates and supplementation rates for land limited and fragmented farms to deliver profitability and resilience with volatile milk prices.
2. Quantify the relationship between dairy farm infrastructure configurations, labour and farm profitability, and develop decision support tools for farmers undertaking farm infrastructure investment.
3. Continue to develop a suite of sustainability indicators and models that can be deployed across national databases, which will be used to generate sustainability metrics for Irish dairy production.
4. Develop robust on-farm sustainability measurement protocols to quantify the carbon footprint on a consistent basis of Irish dairy farms.
5. Create a pipeline of products that can be tested across Moorepark herds for their effect on methane reduction using SF6 techniques. Examples of products that could be tested include Three NOP (active ingredientNitro Oxy propranolol) and seaweed extract (active ingredient Bromoform).
6. Investigate the potential of using precision technologies, big data and data analytics to increase the sustainability and efficiency of pasture-based systems, with a particular focus on economic and environmental returns from investment.

Milking and energy efficiency

- As dairy herd size continues to increase, it will become increasingly important to maintain high milking parlour throughput, while maintaining gentle milking and good udder health. Minimising teat tissue swelling will reduce the risk of bacteria passing through the teat canal after milking, reducing new mastitis infection risk. Success in achieving the goal of gentle milking can be assessed through a number of visual observations, but it is also necessary to quantify the effect of multiple milking machine factors on the teat tissue of cows through the analysis of quarter milk flow rates.
- The concept of automatic milking (AM) has the potential to provide a significant positive effect on work arrangements and flexibility on dairy farms. It could reduce absolute time associated with milking, elimination of the twice daily milking routine requirement, and introduction of flexibility within the farm system. For example, AM could facilitate. Expansion and management of a dairy herd on an outside farm without hiring additional labour, or it could facilitate off-farm income to supplement family farm income. An AM system requires significant financial investment, however, and therefore the system and its optimization need to be thoroughly researched.
- New renewable energy technologies are coming on stream, and many existing technologies are reducing in cost. Do these technologies deliver long term profitability gains for the farmer? Furthermore, farm infrastructure planning and management becomes more complicated with the inclusion of these technologies. Hence, a farm infrastructure decision support tool is required to help farmers make informed decisions regarding these technologies.

Milking and energy efficiency research programme 2017-2021

1. Milking research will provide guidelines for milking machine settings and liner suitability for different teat lengths and shapes in order to minimise teat tissue congestion during peak milk flow and in the over-milking period. This will include risk factors for teat tissue stress and their relationship to new intra-mammary infections.
2. A survey of teat dimensions, liner fit, post milking teat condition and cluster removal strategies on Irish dairy farms will be carried out.
3. Milking management strategies, (a combination of equipment, machine settings and practices) will be developed for the optimal combination of maximum udder health, minimized teat tissue stress and maximum milk yield.
4. The efficiency of AM systems will be optimised (in terms of cow throughput and milking time) in order to enable increased cow numbers per milking robot, to deliver a profitable AM solution to Irish farmers. Research on cow throughput/flow will focus on the grazing management strategy, daily activity budget and behaviour of the cows, together with manipulation of milking frequency at peak lactation and maintaining optimum milkng intervals through encouraging cows to come to the milking unit at appropriate times.
5. A model will be developed to optimise the integration of renewable technologies (e.g. small scale wind turbines, photovoltaic cells, heat recovery and solar thermal). In addition a feedback support tool to optimise decision making around these technologies will be created.

Winter/Liquid Milk Production

- The requirement for year-round supply of milk for fresh consumption currently stands at approximately 480 million litres annually in Ireland. There are approximately 1800 registered liquid milk producers, supplying 900 million litres in total per year as liquid plus manufacturing milk (14% of national output). Data on additional farms supplying winter milk in the absence of registered contracts is limited.
- The proportion of total milk output supplied under winter/liquid contracts varies considerably between individual farms. This results in a wide range of systems and calving patterns within the sector. Technical efficiency and control of production costs at farm level are the principal factors affecting overall profit, irrespective of the proportion of milk supplied under contract.
- Key technical challenges for winter/liquid milk producers remain centred on annual feed costs and herd fertility. Winter milk farms had a feed cost 1.7 cent per litre greater than comparable spring milk farms in 2015, which amounted to >100% of the differential in total variable costs. While much of this is due to the structural cost of supplying winter milk, the large cost variation within the sector indicates significant progress is possible through improved grass utilisation and nutrition practices.
- Fertility performance is the second major underlying issue for winter/liquid milk herds. To some degree this is an artefact of historical breeding and management decisions, where all-year round production and volume-based payments were in place. The option of retaining (recycling) non-pregnant cows and extending lactations has somewhat masked the fertility issue. These practices should now be evaluated for a post-quota scenario, where output per hectare is the first limiting constraint.
- Various pricing mechanisms are employed by processors to create incentives for winter milk production. These generally take the form of bonuses paid on fixed daily amounts of milk supplied across the winter months (October to March). In the post-quota environment, there will likely be a trend toward a reduced proportion of the herd calving in the autumn, and also for the start of calving in the autumn to be delayed. This would have consequences for volumes of surplus-to-contract winter milk, and also the proportion of milk from contracted suppliers delivered at the summer peak. The additional cost and potential value of surplus-to-contract winter milk requires clarification.

Winter/Liquid Milk Production research programme 2017-2021

1. Comparison of block autumn and split spring/autumn calving systems relative to a standard block spring calving model, in terms of grass utilisation and budgets, concentrate feed costs, herd fertility and milk output.
2. Modelling the effects of various calving pattern options on annual milk supply pattern. In particular, this work will seek to clarify the scale of changes to winter milk (Oct-Feb) and peak milk (May-June) volumes for different autumn calving proportions and start dates, relative to changes in production costs.
3. Calculation of the costs associated with sub-optimal fertility at the herd level, for winter milk/ split calving systems. Specifically, the cash cost and full economic cost

of extended lactations, recycling infertile cows between calving seasons and delayed age at first calving will be examined.

4. Evaluation of inter- and intra-herd associations between genetic merit for fertility, age at first calving, and phenotypic fertility performance for winter/liquid milk herds. This work is proposed to be undertaken in collaboration with ICBF.
5. Development and dissemination of management protocols to control hypocalcaemia (milk fever) and associated metabolic disorders in autumn calving herds.
6. Develop grazing management strategies for winter systems of milk production that focus on strategic inclusion of grazed grass in early lactation and also examining an earlier turnout date to enhance overall system profitability.

Milk Quality

- It is vital that Irish dairy products are of the highest quality and safety standards in order to maintain premium position in export markets. Approximately 85% of the milk produced in Ireland is exported as dairy products. Hence, achieving the highest standards for milk quality, safety and transparency is essential if Ireland is to reap the maximum benefit from the projected global increase in demand for high value-added dairy products.
- The bacteriological quality of milk produced on-farm will be influenced by the cleanliness and hygiene of the milk facilities and milking practises. The presence of different types of bacteria in milk needs to be determined to assess suitability for different products. For example, stringent specifications exist for the presence of spore-forming bacteria, thermoduric bacteria and coliforms in milk destined for inclusion in infant milk formula.
- The chemical composition of cleaning products employed to clean milking equipment surfaces, both on-farm and in processing plants, can impact microbe counts in the milk and also residue levels in the final product. The level of contaminants in milk must meet stringent specifications of international customers. The most relevant contaminants currently include trichloromethane, chlorate and quaternary ammonium compounds.
- A wide range of teat disinfectant products are currently on the Irish market. It is timely to investigate their effectiveness in killing teat skin bacteria and their potential contribution as contaminants in milk.
- Milk storage conditions in terms of duration and temperature can have significant implications for both the quality of the milk for processing and energy requirements on-farm. Milk may be stored for different durations of time durations, at different temperatures and may undergo different cooling rates. All of these variations have potential consequences for milk processability, arising from microbial and enzymatic activity.

Milk Quality Research programme 2017-2021

1. Milk samples will be collected from individual farm bulk milk tanks and analysed for a range bacteria including *bacillus cereus*, sulphite reducing clostridia and thermoduric bacteria. These bacteria will be tracked from the farm bulk milk tanks right through the stages of milk processing to final dairy product. Detailed

questionnaires will be completed for each farm to establish the farm factors that may contribute to the presence of these bacteria in milk.

2. Non-chlorine based milking equipment cleaning systems will be evaluated to determine if they can be used as an alternative to chlorine based products to maintain low bacterial levels on plant surfaces and in milk, and also eliminate residues associated with chlorine. New registered cleaning products coming on the market in Ireland will be chemically analysed and details included on the Teagasc detergent listings. A detailed survey and analysis of cleaning products used at processing plants will be undertaken.
3. Up to 150 farms will be visited and milk samples collected and analysed for the presence of residues (Trichloromethane, chlorate, quaternary ammonium compounds, and iodine). Detailed questionnaires will be completed to establish farm factors that may contribute to the presence of those residues in bulk tank milk. Approximately 26,000 industry milk samples will be analysed at Moorepark for the presence of Trichloromethane. In a further study the influence of residue levels from individual farm milk supplies will be tracked from farm bulk milk tanks right through the stages of milk processing to final milk powder product.
4. An evaluation protocol will be developed to measure the efficacy of all teat disinfectant products. The protocol would be used to test the efficacy of products against a wide range of pathogens including *Streptococcus uberis*, *Staphylococcus aureus*, and spore-forming bacteria such as *Bacillius cereus*, which is critical for infant formula manufacture. Products demonstrated to be most effective in reducing bacterial numbers would then be evaluated on farms with regard to new infection rates and teat condition.
5. The effect of pre-cooling (standard plate cooler with well water; ice-cooled water and no plate coolers) and the duration of on farm bulk milk storage on milk quality (microbiological) and energy requirement will be investigated.

Dairy Cow Health and Welfare

- In 2009, The 'Herd Ahead' programme provided the dairy industry with baseline disease prevalence data. This allowed the cost of a number of non-regulated diseases to be calculated. Data are being made openly available to AHI for design of disease control programmes. A number of specific projects will be undertaken to ensure that proposed programmes are effective.
- A full programme on Johne's disease research has been underway for the last four years and will continue for the next five years. This has included large studies on the use of ELISA testing in Irish herds and a study on the economic impact of Johne's disease in Irish herds. Investigations examining the various factors on Irish dairy farms (e.g. TB testing) that act as potential protective mechanisms from development of clinical Johne's disease on Irish farms are continuing. New therapeutic options are also now a real possibility and require investigation.
- Both dystocia and perinatal mortality have potentially serious impacts on cow production and health; These Factors will need to be incorporated into future national economic breeding index (EBI) re-evaluations. Currently we have no published data on the incidence, types and risk factors for congenital defects in Irish dairy herds.
- The quality of Irish milk is of paramount importance given that Ireland produces 15% of the world's powdered infant formula. Blanket dry cow antibiotic treatment of dairy cows is common practice in Ireland, with estimated coverage of 92.7%.

Widespread antibiotic usage presents concerns for public health because of implications for antimicrobial resistance. This is especially relevant concerning antibiotic use in uninfected cows at dry-off. There is a requirement to evaluate internal teat sealants (ITS) as a selective dry cow therapies in cows with low somatic cell count at dry-off (<200,000 cells/ml).

Dairy Cow Health and Welfare research programme 2017-2021

1. Johne's disease research will be expanded over the next five years to include development and evaluation of potential therapeutics for both prevention and cure of the disease.
2. Studies to support AHI in development of appropriate Irish control programmes for non-regulated diseases (e.g., appropriate vaccination programmes for IBR) will be conducted.
3. Develop, lead and implement a research programme in the area of dairy cow and calf welfare with particular emphasis on risk factors for dairy cow and calf welfare in Irish pasture-based systems. The objective would be to increase the public and marketing image of Irish dairy products.
4. Investigate the potential for reducing the risk of generating antimicrobial resistance on Irish dairy farms. This is a long-term programme (>10 years) and a preliminary review will initially be conducted to determine how best to appropriately allocate resources in order to achieve the best return on investment for Ireland.
5. Evaluate the use of internal teat sealants without antibiotics in preventing new intra-mammary infection during the dry period in cows with low milk somatic cell count (<200,00 cells/ml) at drying off; likewise evaluate the benefit of infusing internal teat sealants in heifers 4 to 6 weeks pre-calving on the prevalence of intra-mammary infection post-calving.
6. Establish active surveillance research in sentinel dairy herds for the probable reappearance of Schmallenberg virus, as has already occurred in other EU countries recently.
7. Establish a research programme on characterising and mitigating the animal health and biosecurity risks inherent in dairy heifer contract rearing.

Dairy Cow Nutrition

- There are large gaps in the knowledge of the digestion and utilisation of feed in grass-based production systems. The Cornell Net Carbohydrate and Protein System (CNCPS) is a ruminant nutrition model, which predicts intake and rumen degradation of feeds, intestinal digestion and metabolism and is widely used world-wide, but is not currently adapted for Irish pasture-based systems.
- Traditionally the energy content of grass was estimated from the grass Organic Matter Digestibility. Other grass quality measurements may be a better predictor of total energy intake, however, particularly in autumn when milk production performance is suboptimal relative to the presumed quality of the grazing diet being offered.
- Increased stocking rates and variable over-winter and spring grass growth rates can lead to reduced feed supply in spring. As a consequence of milk price volatility and the high cost of supplementary feeds, it is necessary to establish the effects of both restricted pasture feeding levels in early lactation and the response to supplementary feed.

- To date it is unclear what concentrate ingredients would elicit the maximum response at pasture in spring/autum and this needs to be identified.
- There is widespread interest in using white clover in grazing swards to reduce nitrogen fertiliser requirements and produce a high quality grazing sward throughout the grazing season, particularly in summer and autumn. Research to date has shown an increase in dairy cow milk production performance when >20% white clover is present in the sward. The physiological mechanisms responsible for the increased milk yield are currently poorly understood. Furthermore, the impact of clover inclusion on milk composition, milk processability, and the environmental implications are not known. One major issue precluding adoption of white clover is the risk of grazing animals developing bloat.
- The processing industry is increasingly looking to farmers to produce high quality milk, from grass and grass clover swards, over an increasingly long grazing season. In addition, the milk produced should provide a protein profile to optimally produce milk powders and a fatty acid profile to optimally produce butter. Both milk protein and fatty acid profile are controlled by dairy cow genetics, but are also influenced by diet.

Dairy Cow Nutrition research programme 2017-2021

1. Evaluate and modify the CNCPS for pasture-based diets typical of Irish grazing systems.
2. Increase our understanding of the basic biological mechanisms that underpin the nutritional status of Irish grazing dairy cows. This will be achieved by utilising novel feed chemistry analyses combined with dynamic nutrition modelling.
3. Investigate the principal factors that restrict dairy cow performance at pasture. A key objective is to identify the causes of suboptimal milk production in grazing dairy cows in late lactation and to develop nutritional strategies to overcome this
4. Establish the response to pasture and concentrate (including type) in spring and autumn i.e. early and late lactation.
5. Investigate the potential of diverse supplementary feeds during spring and autumn to favourably alter milk protein and fatty acid profiles of milk.
6. Profile the milk protein and fatty acid composition of milk produced by grazing dairy cows across the entire grazing season, to enhance the marketing image of Irish dairy products.
7. Understand the risk factors associated with bloat in perennial ryegrass/white clover swards; and develop bloat mitigation strategies.

Milk production on heavy soils and the BMW region

- The overall aim of the Heavy Soils programme is to increase the profitability and sustainability of commercial farms on poorly drained soils through increased grass production and utilization. This relies on a range of strategies: installation of land drainage systems; improved soil fertility and grassland management; and development of an appropriate farm infrastructure.
- The beginning of the grass growing season is normally considered to be some 7 weeks later in the Northeast compared with the extreme south. Similarly, there is a difference of some 6 weeks at the end of the season so that the length of the growing season varies from 330 days in the extreme south to 240 days in the Northeast.

- The grazing season can also be shorter on heavy soils. Dairy farming in these areas is a key enterprise dependent on grass farming, but the grazing season is shortened due to impeded drainage, topography, weather and northerly aspect.

Milk production on heavy soils and the BMW region research programme 2017-2021

1. On poorly drained land, drainage is vital to reduce volatility and sustain viable farm enterprises. The heavy soils programme is focussed on developing and demonstrating site-specific land drainage design methods to ensure efficient drainage can be achieved regardless of variations in soil/site conditions. A site-specific drainage system (based on specific soil type and site conditions) has been installed (approx. 2 ha) in each of the 9 participating farms. These range from depths of 0.9 to 1.7 m and are supported by mole drains, gravel mole drains or sub-soiling where appropriate. The demonstration element of this work is on-going and involves showcasing the works carried out to farmers and contractors at public open days held on programme farms.
2. A whole-farm evaluation of soil fertility on each programme farm is also carried out on a paddock by paddock basis through annual soil sampling and recording of all inputs and off-takes to monitor change over time. Results to date have shown that programme farms, in line with national trends, are handicapped by low soil pH, and low soil P and K levels. Furthermore, the chemical make-up of such soils (principally excessive acidity) means any improvements in fertility require large financial investment.
3. The effect of grazing season length on animal and pasture productivity in the BMW region will be evaluated (Ballyhaise farmlet study).

Technology Transfer /Dissemination of Research Results

At all public events the support of the Dairy Research Trust has been and will be acknowledged for their financial support. The new developed Dairy Research Trust logo is used is used on all publication and boards at open days.

- Researchers recognise that research results are only of value towards improving the profitability of producers when they reach the end-user and are implemented. There are strong links between research and the advisory service, where latest technology is made available to dairy farmers. A national Open Day is planned for Teagasc Moorepark next year for the 4th of July 2017, where all the recent developments in technology will be displayed.
- Over the last four years a number of Open days/public events have been delivered to highlight the results coming from the research programme. Open days have been held in Clonakilty Agriculture College, Ballyhaise Agriculture College, Greenfield Dairy Farm, Shinagh Dairy farm, Solohead Research Farm, Johnstown Castle Research Farm, Dairygold Research Farm and on the Heavy Soils farms throughout the country.
- In addition to Open Days a series of grassland farm walks have been delivered on commercial farms throughout the country in both spring and autumn 2016 to

demonstrate the benefits of implementing good grassland management practices at farm level as part of the Dairy Research Trust.

- Since the Dairy Research Trust programme started there has been 32 'Moorepark Dairy Research Updates' published, each one summarising results coming from the programme. These have been distributed at public events and can be obtained on both the Teagasc and Dairy Research Trust web sites.
- Over the last four years Teagasc Moorepark staff, in association with advisory staff, has delivered joint programmes at public events with dairy co-ops. This has been a major benefit to all three groups concerned.
- On an on-going basis, Teagasc Research and Demonstration farms facilitate large numbers of discussion groups visiting these farms. Some research farms have up to 50 visits annually from discussion groups.
- In the future, greater use will be made of modern telecommunication technology in transferring information to farmers. Text messaging has been used successfully over the last four years; in the future its hoped to make greater use of social media and YouTube videos.

Linkages

- This programme is linked to the Universities through the Walsh Fellowship scheme.
- At present there are 37 Walsh Fellows undertaking research in the dairy production research programme under the joint supervision of Teagasc and University personnel. A high proportion of these students are linked to University College Dublin.
- There are links with both the supply and processing sides of the dairy industry and with ICBF.

Level of grant sought

Teagasc is seeking a total budget contribution of €1.1m from the Dairy Research Trust. This together with a Teagasc budget allocation of €5.0 m and levered competitive research funding of €3.1m will give a total annual budget allocation of €9.3 for the expanded dairy production research programme. Table 2 shows how the financial contribution will be used; on average over the five years plus the total amount. Table 2 also shows the staff that will be committed to the programme. The budget is also broken down by sub-programme area.

Table 2. Proposed breakdown of annual and total resource allocation of Dairy Research Trust contribution		
	Cost (€,000/ year)	**Total (€,000)**
Dairy cow genetics		
1 Geneticist	78	390
Dairy cow reproduction		
1 Walsh Fellows	22	66
Grass breeding and evaluation		
1 technologist	54	268
Grazing management		
2 Grazing Scientists	104	520
1 farm staff	40	201
Milk production systems and sustainability		
1 technician	41	207
1 farm staff	38	191
Winter/liquid milk production		
1 Walsh Fellow	22	88
Milk quality		
1 Veterinary Scientist	48	242
Milking and energy efficiency		
1 Walsh Fellow	22	88
Dairy cow nutrition and increasing added-value		
1 Dairy Cow Nutrition Scientist	48	240
1 Walsh Fellow	22	88
Milk production on heavy soils and BMW regions		
1 technician	49	244
Dairy cow health and welfare		
1 Veterinary Scientist	48	242
1 Walsh Fellow	22	88
People in dairying		
1 People/labour Scientist	53	266
Total staff costs	**689**	**3147**
Travel	50	250
Consumables	150	750
30% overheads on contract staff costs	206.7	944.1
Total	**1095.7**	**5091.1**