



**An Roinn Talmhaíochta,
Bia agus Mara**
Department of Agriculture,
Food and the Marine

Research Stimulus Fund

Final Report

'Profitable production of bull beef to market specification while ensuring optimum quality for the consumer (BullBeef)'

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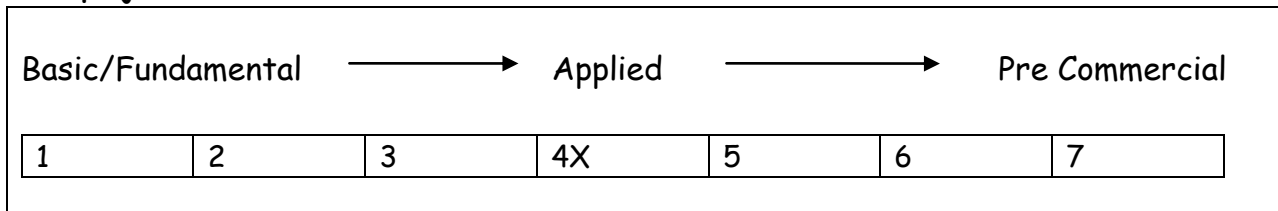
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Irish Cattle Breeding Federation: Dr. Andrew Cromie, Dr. Stephen Conroy

Please place one "x" below in the appropriate area on the research continuum where you feel this project fits



Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report:

Priority Area (s)	H Food for Health Sustainable Food Production and Processing
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Key words: *Bulls, production systems, beef quality*

1. Rationale for Undertaking the Research

Approximately 910,000 male cattle are slaughtered annually in Ireland and more than 90% of Irish beef is exported. Beef from late maturing suckler-bred animals is generally exported to higher-priced European markets, beef from early maturing breed crosses has a significant role in premium niche markets and beef from the dairy herd is primarily exported to UK markets. A wide range of beef systems are operated with the two predominant systems today being the grass-based dairy and suckler calf-to-beef. Male animals are generally produced as steers at ca. ≥ 24 months of age, on grass-based systems. Grass-fed steer is a point of difference for Irish beef in many high-value EU markets. The superior growth and feed conversion efficiency of bulls compared to steers however make bulls attractive to producers. The proportion of the male slaughter represented by young bulls varies from year to year (e.g. 13% in 2008, 22% in 2017 and 23% in 2018 (Department of Agriculture, Food and the Marine, Beef carcass classification and price reporting section, Annual Report, 2018)). Traditionally, bulls were reared indoors on a high energy ration which is a relatively expensive production system. Exploiting grazing is one strategy to decrease the cost of production but meeting the abattoir specifications of animal age and carcass fat score and weight is likely to be a challenge. In addition the impact of modifications of the traditional production system on the appearance and eating quality of bull beef were largely unknown. This large, multi-institutional project addressed novel production systems for bulls, the impact on beef quality and whether current abattoir specifications are valid from a meat quality perspective.

2. Research Approach

The over-arching tasks concerned the modification of production systems for suckler and dairy-origin bull beef to increase profitability and the assessment of the resulting beef for market-relevant quality characteristics and environmental impact. Bull production data were collected and analysed. Detailed compositional analysis (proximate, fatty acids, collagen, texture) of beef samples was undertaken. Sensory analysis of beef was carried out. Large data sets were statistically analysed. Underpinning research tasks focused on elements from "farm to fork" that limit achievement of market specifications. Since carcass fat score is a key market specification, the underlying biology of fat deposition was explored.

In the course of the project and in consultation with stakeholders, the following modifications were approved:

A comparison of bulls and steers was introduced for both dairy and suckler bull beef production systems.

Meat quality assessment was expanded from the striploin to sirloin and rump muscles.

An under 16 months of age slaughter point for suckler bulls was added.

Carcass hanging of dairy origin bulls and steers was examined.

3. Research Achievements/Results

- When finished from pasture at the same age, ca. 19 months, carcasses from spring-born, suckler-bred early-maturing breeds were lighter, fatter, and had poorer conformation than late-maturing breeds; bulls had greater growth, live weight, better kill-out proportion, a heavier carcass, better carcass conformation score and a lower carcass fat score than steers.
- Carcasses of early-maturing breed bulls slaughtered at 19 months of age from pasture were lighter but adequately finished, with or without concentrate supplementation during the latter half of the grazing season (i.e. ca. 4.0kg daily for 95 days), whereas the heavier, late-maturing breed bull carcasses were only adequately finished when supplemented.
- Carcasses of both early-and late-maturing breed suckler bulls were inadequately finished from pasture, with or without concentrate supplementation at 15 months of age.
- For dairy origin bulls, achieving market specifications is challenging when slaughtered under 16 months of age and the profitability of this system is particularly vulnerable to increases in concentrate costs.
- The most profitable production system for dairy origin bulls was finishing as 19 month bulls with supplementation in the final 100 days at pasture. However, the possibility of a price discount due to the animals being older than the 16 months currently required in many markets needs to be considered
- There was some evidence that production system *per se* may have a small negative effect on eating quality. When suckler bulls from early or late maturing breed sires were slaughtered at 380 kg carcass from an *ad libitum* concentrate diet or grazed prior to finishing on an *ad libitum* concentrate diet, the tenderness rating by trained assessors was lower for the grass-based system. The scale of this decrease is unlikely to be detected by untrained consumers.
- Continental breed-sired bulls and steers were compared within 2 production systems; the striploin from steers was fatter and rated more highly for tenderness and acceptability than the striploin from bulls. The absolute differences in eating quality were however, small.
- There is little commercially important difference in tenderness or overall liking of striploins from continental breed sired suckler bulls slaughtered between 15 and 22 months of age or from dairy bulls slaughtered at 16, 19 or 21 months of age.
- Finishing both dairy beef and suckler beef offspring at younger ages reduced the greenhouse gas emissions of the system

4. Impact of the Research

A wide range of suckler and dairy origin bull production systems and the associated effects on meat quality were examined in this project. The main implications are:

- Grazing can have a significant role in bull beef production.

- Market specifications based on age/weight or carcass fatness are not supported by major differences in eating quality

The main stakeholders/end users of the information from this project are beef farmers, beef processors, ICBF, Bord Bia, Teagasc advisory service, agri-consultants and scientific community.

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

Excellent collaborative links were formed in the course of the project. This was facilitated initially by the formation of a stakeholder advisory group at the start of the project. The stakeholder advisory group included representatives of the meat industry (Meat Industry Ireland), Bord Bia (the Irish Food Board), meat processors and farmer associations. The functions of the advisory group were: (i) to offer advice on work proposed as the project progressed and (ii) to ensure that the project tasks met stakeholder needs. Beef production studies were conducted in two Teagasc locations and involved different abattoirs/meat processors. Samples were transferred around four institutions within the project which required excellent collaboration and co-ordination. Publications from the project were collaborative.

(ii) Outcomes where new products, technologies and processes were developed and/or adopted

The project did not set out to develop a new product *per se*. New grass-based bull beef production systems were developed and evaluated.

(iii) Outcomes with economic potential

The output of the project is exploitable by the producers and processors of Irish beef. The Irish food sector needs to target high value markets through increased value-added output (Food Harvest, 2020); it is therefore essential that the quality of food products targeted for these markets be well characterised and underpinned by science. The project demonstrates the feasibility of lower cost systems for producing bull beef and provides information to address concerns in some markets about the influence of age at slaughter on the quality of bull beef relative to steer beef. In addition, the data generated facilitates examination of the relevance of meat quality to current market specifications based on age and carcass fatness.

(iv) Outcomes with national/ policy/social/environmental potential

The research supports the production of bull beef to meet Irish national and export needs. The data generated facilitates discussion between processors and retailers about

perceived quality issues with bull beef and so can aid marketing strategies for Irish beef. The environmental assessment of the production systems within the project can contribute to the national debate of greenhouse gas emissions.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

Acceptable Format: Walsh, D.R., Murphy, O., Cosgrave, J. (2008). Echinococcosis - an international public health issue. Research in Veterinary Science 774, 891-902.

1. Murphy, B., Crosson, P., Kelly, A.K. and Prendiville, R. 2017. An economic and greenhouse gas emissions evaluation of pasture-based dairy calf-to-beef production systems. *Agricultural Systems*, 154, 124-132
2. Murphy, B., Crosson, P., Kelly, A.K. and Prendiville, R. 2017. Animal performance and economic implications of alternative production systems for dairy bulls slaughtered at 15 months of age. *Irish Journal of Agricultural and Food Research*, 56, 93-103.
3. Lenehan, C., Moloney, A.P., O'Riordan, E.G., Kelly, A. and McGee, M. 2017. Pasture-based finishing of early-maturing sired suckler beef bulls at 15 or 19 months of age. *Advances in Animal Biosciences*, 8: S1, 28-32.
4. Lenehan, C., Moloney, A.P., O'Riordan, E.G., Kelly, A. and McGee, M. 2017. Comparison of rolled barley with citrus pulp as a supplement for growing cattle offered grass silage. *Advances in Animal Biosciences*, 8: S1, 33-37.
5. Moran, L., O'Sullivan, M.G., Kerry, J.P., Picard, B., McGee, M., O'Riordan, E.G. and Moloney, A.P. 2017. Effect of a grazing period prior to finishing on a high concentrate diet on meat quality from bulls and steers. *Meat Science*, 125, 76-83
6. Moran, L., O'Sullivan, M.G., Kerry, J.P., McGee, M., McMennamin, K., O'Riordan, E.G. and Moloney, A.P. 2017. Growth paths for suckler bulls slaughtered at 19 months of age: a meat quality perspective. *Advances in Animal Biosciences* 8: S1, 60-63
7. Nian, Y., Zhao, M., O'Donnell, C.P., Downey, G., Kerry, J.P. and Paul Allen, P. 2017. Assessment of physico-chemical traits related to eating quality of young dairy bull beef at different ageing times using Raman spectroscopy and chemometrics. *Food Research International*, 99, 778-789.
8. McGee, M., O'Riordan, E., Kenny D. and Moloney A. 2018. Beef-cattle production: Feed-efficiency *Veterinary Ireland Journal*, 8, 239-242.
9. Nian, Y., Allen, P., Harrison, S.M and Kerry, J.P. 2018. Effect of castration and carcass suspension method on the quality and fatty acid profile of beef from male dairy cattle. *Journal of the Science of Food and Agriculture*, 98, 4339-4350.
10. Murphy, B., Kelly, A.K. and Prendiville, R. 2018. Alternative finishing strategies for Holstein-Friesian bulls slaughtered at 15 months of age. *Agriculture and Food Science*, 27, 28-37.
11. Murphy, B., Crosson, P., Kelly, A.K. and Prendiville, R. 2018. Performance, profitability and greenhouse gas emissions of alternative finishing strategies for Holstein-Friesian bulls and steers. *Animal*, 12, 2391-2400.

12. Moran, L., Andres, S., Allen, P. and Moloney, A.P. 2018. Visible and near infrared spectroscopy as an authentication tool: Preliminary investigation of the prediction of the ageing time of beef steaks. *Meat Science*, 142, 52-58
13. Mezgebo, G.B., Monahan, F.J., McGee, M., O'Riordan, E.G., Marren, D., Listrat, A., Picard, B., Richardson, R.I. and Moloney, A.P. 2019. Extending the grazing period for bulls, prior to finishing on a concentrate ration: Composition, collagen structure and organoleptic characteristics of beef. *Foods*, 8, 278.
14. Moloney, A.P., Blanco, C., Vandenbulcke, T., McGee, M and O'Riordan E.G. 2020. Growth, carcass and adipose tissue characteristics of dairy origin bulls offered concentrate rations of increasing energy density. *Livestock Production Science*, (Submitted)
15. Moran, L., Wilson, S.S., O'Sullivan, M.G., McGee, M., O'Riordan, E.G. Monahan, F.J., Kerry, J.P. and Moloney, A.P. 2020. Quality of three muscles from suckler bulls finished on concentrates and slaughtered at 16 months of age or slaughtered at 19 months of age from two production systems. *Animal* (in press).
16. Moran, L., Wilson, S.S., McElhinney, C.K., Monahan, F.J., McGee, M., O'Sullivan, M.G., O'Riordan, E.G., Kerry, J.P. and Moloney, A.P. 2019. Suckler bulls slaughtered at 15 months of age: Effect of different production systems on the fatty acid profile and selected quality characteristics of *Longissimus thoracis*. *Foods*, 8, 264.
17. Moran, L., Barron, L.J.R. Wilson, S.S., O'Sullivan, M.G., Kerry J.P., Prendiville, R. and Moloney, A.P. 2020. Effect of post-mortem tenderization techniques on the quality of meat from Holstein-Friesian bulls and steers: Pelvic hanging and meat ageing. *Food Research International*, (Submitted)
18. Siphambili, S., Moloney, A.P., O'Riordan, E.G. McGee, M. and F.J. Monahan, F.J. 2020. The effects of graded levels of concentrate supplementation on colour and lipid stability of beef from pasture finished late maturing bulls. *Animal*, 14, 656-666.
19. Siphambili, S. Monahan, F.J., O'Riordan, E.G., McGee, M. and Moloney, A.P. 2020. The effect of grass finishing and the residual effect of pasture prior to finishing on concentrates on the shelf stability of late-maturing bull beef. *Animal Production Science*, (In press).

(ii) Popular non-scientific publications and abstracts including those presented at conferences

1. Prendiville, R., Murphy, B. and Swan. B. Teagasc Beef Advisory Newsletter. Alternative finishing strategies for Holstein-Friesian bulls slaughtered at 19 months. November 2015
2. Prendiville, R., Murphy, B. and Swan. B. Teagasc Beef Advisory Newsletter. Options for male dairy-type calves. April 2015

3. McGee, M., C. Lenehan, C. McMenamin, K., O'Riordan, E and Moloney, A. Teagasc Beef Advisory Newsletter. Feeding weanlings for better growth: Effects of supplementary concentrate type and protein level on growth of suckler-bred weanling bulls offered grass silage. November 2014
4. McGee, M., Lenehan, C., O'Riordan, E. and Moloney, A. Teagasc Beef Advisory Newsletter. Maize vs. Barley: Effect of partially replacing rolled barley with processed maize on the performance of finishing cattle offered a high concentrate diet. January 2015.
5. McGee, M., Lenehan, C., O'Riordan, E. and Moloney, A. Teagasc Beef Advisory Newsletter. Finishing Bulls: Finishing autumn-born bulls from pasture in the first half of the grazing season using concentrates. May 2015
6. McGee, M. Irish Grassland Association - Quarterly Newsletter - Issue No. 30. Feed efficiency in beef finishing systems. Winter, 2015
7. O'Riordan, E.G., McGee, M, Moloney, A.P. and Crosson, P. TResearch Summer Issue. Producing suckler origin male cattle. 01/05/2016
8. Murphy, B., Swan, B., Prendiville, R. Irish Farmers Journal. Think systems and breed type.16 January, 2016.
9. Prendiville, R., Murphy, B. and Swan, B. Teagasc Beef Advisory Newsletter. Finishing strategies. April, 2016
10. Prendiville, R., Murphy, B., Swan, B. and Crosson, P. TResearch Summer Issue. Male dairy calf to beef systems. 01/05/2016
11. O'Riordan, E.G., O'Kiely, P. and McGee, M. Teagasc Beef Advisory Newsletter. Winter feeding of weanlings. November 2015.
12. McGee, M., Lenehan, C., O'Riordan, E. and Moloney, A, Teagasc Beef Advisory Newsletter. Comparison of rolled barley with citrus pulp as a supplement for growing cattle offered grass silage. May, 2016.
13. McGee, M., Lenehan, C., Moloney, A. and O'Riordan, E. Teagasc Beef Advisory Newsletter. Finishing suckler beef bulls [Finishing early-maturing breed suckler beef bulls on pasture at 15 or 19 months of age]. March 2017.
14. Moloney, A. Teagasc Beef Advisory Newsletter. The best from bulls. March 2017.
15. O'Riordan, E.G., McGee, M. and Moloney, A.P. Teagasc Beef Advisory Newsletter, Cutting through the bull [Carcass growth and feed efficiency of early and late-maturing breed suckler bulls].December 2018.

16. Moloney, A.P., McGee, M., Moran, L. and O'Riordan, E.G. Teagasc Beef Advisory Newsletter. Effects of finishing method on beef. June 2018
17. McMenamin, K., Marren, D., McGee, M., Moloney, A.P., Kelly, A. and O'Riordan, E.G. Effect of growth rate during the first indoor winter and forage type during finishing on performance to slaughter of late-maturing suckled bulls. Proceedings: Agricultural Research Forum (2014). Page 33.
18. McMenamin, K., Marren, D., McGee, M., Moloney, A.P., Kelly, A. and O'Riordan, E.G. Effects of concentrate supplementation level during winter and subsequently at pasture on performance and carcass traits of late-maturing suckler bred bulls. Proceedings: Agricultural Research Forum (2014). Page 27.
19. McMenamin, K., Marren, D., McGee, M., Moloney, A.P., Kelly, A. and O'Riordan, E.G. Effects of differential supplementation during the first winter and at pasture on suckler bulls. Proceedings: European Association of Animal Production (2014). Page 265.
20. Murphy, B., French, P., Kelly, A., Swan, B and Prendiville, R. Alternative finishing strategies and influence of concentrate supplementation level during the first season at pasture on Holstein-Friesian bulls, slaughtered at 19 months of age. Proceedings: Agricultural Research Forum (2014). Page 26.
21. Murphy, B., Crosson, P., Kelly, A.K. and Prendiville, R. Economic evaluation of alternative finishing strategies for dairy bred bulls slaughtered at 19 months of age Proceedings: Agricultural Research Forum (2014). Page 135.
22. Nian, Y.Q., Allen, P., Prendiville, R and J. Kerry, J. Fatty acid composition of young dairy bull beef is affected by feeding treatment. Proceedings: 44th Annual Food Science Conference, Teagasc Food Research Centre, Moorepark (2015).
23. Murphy, B., Kelly, A.K., Swan, B. and Prendiville, R. Effects of finishing strategy, genotype and level of concentrate supplementation on the performance of dairy bulls slaughtered at 15 months of age. Proceedings: Agricultural Research Forum (2015).
24. Murphy, B., Kelly, A.K. and Prendiville, R. Alternative finishing strategies for Holstein-Friesian bulls slaughtered at 19 months of age. Proceedings: European Association of Animal Production (2015).
25. Lenehan, C., K. McMenamin, A.P. Moloney, E.G. O'Riordan, A. Kelly and M. McGee. Effects of supplementary concentrate type and protein level on growth of suckler-bred weanling bulls offered grass silage. Proceedings: Agricultural Research Forum (2015). Page 74.

26. Lenehan, C., Moloney, A.P., O'Riordan, E.G. Kelly, A and McGee, M. Finishing autumn-born bulls from pasture in the first half of the grazing season using concentrates. Proceedings: Agricultural Research Forum (2015). Page 39.
27. Lenehan, C., Moloney, A.P., O'Riordan, E.G. Kelly, A and McGee, M. Effect of substituting barley with maize on the performance of suckler-bred bulls offered a high concentrate diet. Proceedings: Agricultural Research Forum (2015). Page 82.
28. McMenamin, K., Lenehan, C., McGee, M., Moloney, A.P., Kelly, A. and O'Riordan, E.G. The production of suckler bulls at 16-months of age: a comparison of pasture and indoor finishing. Proceedings: Agricultural Research Forum (2015). Page 57.
29. McMenamin, K., Marren, D., McGee, M., Moloney, A.P., Kelly, A. and O'Riordan, E.G. A comparison of late-maturing suckler-bred bulls and steers in two contrasting production systems. Proceedings: Agricultural Research Forum (2015). Page 53.
30. McMenamin, K, A.P. Moloney, A.P. McGee, M., Kelly, A and O'Riordan, E.G. Grass-based production systems for late-maturing sired suckler bulls. Proceedings: European Association of Animal Production (2016).
31. Moloney, A.P., McGee, M., O'Riordan, E.G., Marren, D., Mazgebo, G., Monahan, F. and Richardson, I. Influence of grazing prior to finishing on a high concentrate ration, on colour and sensory characteristics of muscle from early or late maturing bulls slaughtered at a the same carcass weight. Meat Science, 112, 118-119 (2016)
32. Moran, L., O'Sullivan, McGee, M., McMenamin, K, O'Riordan, E.G and Moloney, A.P. Growth paths for suckler bulls slaughtered at 19 months of age: A meat quality perspective. Proceedings: European Association of Animal Production (2016).
33. Moran, L., Hossain, M.B., Nian, Y., Allen, P., Rai, D. and Moloney, A.P. Determination of 4-Hydroxyproline in total and soluble collagen fractions of meat. Proceedings: IUFoST. (2016).
34. Mezgebo, G., Moloney, A.P., McGee, M., O'Riordan, E.G, Marren, D., Richardson, R.I. and Monahan, F.J. Compositional and sensory qualities of beef from bulls slaughtered at different ages. Proceedings: IUFoST. (2016).
35. Murphy, B., Kelly, A. K. and Prendiville, R. Contrasting finishing strategies for Holstein-Friesian bulls slaughtered at 19 months of age. Proceedings: British Society of Animal Science (2016). Page 47.

36. Murphy, B., Kelly, A. K. and Prendiville, R. Finishing strategies for dairy bulls slaughtered at 15 months of age. Proceedings: European Association of Animal Production (2016).
37. Murphy, B., Kelly, A. K. and Prendiville, R. Alternative finishing strategies for dairy steers. Proceedings: European Association of Animal Production (2016).
38. Crosson, P., Murphy, B. and Prendiville, R. Greenhouse gas emissions from alternative calf to beef production systems. Proceedings: European Association of Animal Production (2016).
39. Murphy, B., Kelly, A. K. and Prendiville, R. The effects of production system and finishing strategy on male calves from the dairy herd. Proceedings: Teagasc Walsh Fellowship Seminar, RDS, Dublin, Ireland.
40. Lenehan, C., Moloney, A.P. O'Riordan, E.G., Kelly, A. and McGee, M. Pasture-based finishing of early-maturing sired suckler beef bulls at 15 or 19 months of age. Proceedings: European Association of Animal Production (2016). Page 709.
41. McGee, M. Feed efficiency in beef finishing systems. Irish Grassland Association Journal, 50: 164-169.
42. Coyle, S., O'Sullivan, M.G., Moloney, A.P. and Kerry J.P. Comparison of sensory profiles of bovine muscles (LD, GM, ST) using traditional and rapid analysis mapped with affective testing. Proceedings; 62nd International Congress of Meat Science and Technology (2016)
43. Coyle, S. O'Sullivan, M.G. Moloney, A.P. and Kerry J.P. Sensory comparison of muscles (LD, GM, ST) from charolais and limousin bulls fed on pasture, grass silage and concentrate supplementation. Proceedings: 62nd International Congress of Meat Science and Technology (2016).
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46. Nian, Y., Kerry, J.P. Prendiville, R. and Allen, P. Effect of castration and ageing time on the quality of beef from dairy cattle. Proceedings: IUFoST (2016).
47. Ferguson, N. Kelly, A.K., Moloney, A.P. and Kenny, D.A. Effect of milk replacer fat content during calfhood and cereal type and supplemental saturated fat inclusion in the finishing ration on the performance and carcass composition of

- young Holstein Friesian bulls. *Journal of Animal Science*. 95 (supplement 4): 295-296. (2017).
48. Regan, M., Lenehan, C., Moloney, A.P., O'Riordan, E.G., Kelly, A. and McGee, M. Pasture-based finishing of early- and late-maturing breed suckler bulls at 19 months of age. *Proceedings: European Association of Animal Production* (2017).
 49. Siphambili, S., Monahan, F.J., McGee, M., O' Riordan, E.G. and Moloney, A.P. Breed and production system effects on meat on meat quality characteristics of pasture finished bulls. *Proceedings: 63rd International Congress of Meat Science and Technology* (2017).
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 51. Moloney, A.P. O'Riordan, E.G., McGee M. and Moran, L. Grass-based suckler bull production: Muscle colour and fibre composition. *Proceedings: 63rd International Congress of Meat Science and Technology* (2017).
 52. Moloney, A.P. O'Riordan, E.G., Ferguson, N., McGee M. Keenan, J.B. and Mooney, M. H. Plasma and muscle response to pre-slaughter mixing of suckler bulls. *Proceedings: European Association of Animal Production* (2017).
 53. Nian, Y., Kerry, J.P, Zhao, M. and Allen, P. Assessment of beef quality traits from young male dairy cattle using near infrared spectroscopy. *Proceedings: 63rd International Congress of Meat Science and Technology* (2017).
 54. Regan, M., Lenehan, C., Moloney, A.P., O'Riordan, E.G., Kelly, A.K. and McGee, M. Finishing late-maturing suckler steers and bulls from pasture: Effect of concentrate supplementation. *Grassland Science in Europe* 23: 485-487 (2018)
 55. McGee, M., O'Riordan, E.G.C. Lenehan, C., A. Kelly, A. and A.P. Moloney, A.P. Pasture finishing of early-maturing suckler-bred cattle at 19 months of age: bulls versus steers. *Proceedings: British Society of Animal Science* Page 205 (2018).
 56. Moloney, A.P., O'Riordan, E, G, McGee, M. and Prendiville, R.P. Innovative bull production systems and beef quality. *TResearch*, 13 (4), (2018).
 57. Siphambili, S., Moloney, A.P., O'Riordan, E.G., McGee, M .and Monahan, F.J. Production system and gender effects on fat deposition and indicators of tenderness of beef from late maturing breeds. *Proceedings: British Society of Animal Science*. Page 065 (2018).
 58. Ferguson, N. Kelly, A.K., Dick, J.R., Moloney, A.P. and Kenny, D.A. The effect of milk replacer fat content on the performance and carcass composition of pre-

weaned Holstein -Friesian bull calves. Proceedings: British Society of Animal Science. Page 137 (2019).

59. Ferguson, N. Kelly, A.K., Moloney, A.P., McCormack, J. and Kenny, D.A. The effect of milk replacer fat content on adipocyte development in subcutaneous adipose tissue of pre-weaned Holstein Friesian bull calves. Proceedings: British Society of Animal Science (2016). Page 141 (2019).
60. Moloney, A.P., McGee, M. O'Riordan, E.G., Monahan, F.J. and Moran, L. The potential of near infra-red spectroscopy (NIRS) to authenticate the dietary history of beef. Proceedings: British Society of Animal Science. Page 005 (2019).
61. Moloney, A.P., Prendiville, R., Allen, P., O'Sullivan, M.G., Kerry, J.P. and Moran, L. Colour and tenderness of muscle from Holstein Friesian bulls (19 months) and steers (24 months): Effect of carcass suspension. Proceedings: 64th International Congress of Meat Science and Technology (2018).
62. Moloney, A.P., O'Riordan, E, G, McGee, M., O'Sullivan, M.G., Kerry, J.P. Coyle, S., Monahan, F.J., Siphambili, S. and Moran, L. Grass-based production systems for late-maturing suckler bulls: Carcass characteristics and meat eating quality. Proceedings: 64th International Congress of Meat Science and Technology (2018).

(iii) National Report

Moloney, A.P. (2020). Technology update, Teagasc

(iv) Workshops/seminars at which results were presented

1. Work Package Leaders. Stakeholder advisory group meeting. Presentation of project, discussion of industry perspectives. 25/06/13
2. Work Package Leaders. Stakeholder advisory group meeting. Presentation of project, discussion of industry perspectives. 05/06/14
3. Work Package Leaders. Stakeholder advisory group (meat sub-committee) meeting. Discussion on modifications to Task 8. 15/05/15
4. Crosson, P., Murray, M., O'Riordan, E. and McGee, M. Teagasc National Beef Conference. Planning to profit from beef production - principles and guidelines. 13/10/2015

5. Prendiville, R., Crosson, P., Murphy, B. and Swan, B. Irish Grassland Association. Profitable dairy calf to beef production systems. 11/06/2015
6. O'Riordan, E., McGee, M., Moloney, A., Crosson, P., O'Kiely, P., Marren, D., McMenamin, K. and C. Lenehan, C. Teagasc, National Beef Conference. Feeding strategies to optimise performance from pasture in steer and bull finishing systems. 13/10/2015
7. O'Riordan, E.G., McGee, M, Moloney, A.P., Crosson, P., Marren, D, McMenamin, K. and Lenehan, C. Beef 2016 (Grange Open Day Book). Male sucker cattle production. 05/07/16
8. Prendiville, R. and Peppard, G. Beef 2016 (Grange Open Day Book). Blueprints for dairy calf to beef systems. 05/07/2016
9. Murphy, B., Swan, B. and Prendiville, R. Beef 2016 (Grange Open Day Book). Dairy calf to beef production: the real alternative. 05/07/2016
10. McGee, M. Proceeding of Society of Feed Technologists, Ruminants Conference, Coventry. Aspects of feed efficiency in beef production, 21/04/16
11. Prendiville, R. and Murphy, B. Teagasc National Beef Conference, Athlone, Roscommon. Alternative finishing strategies for dairy calf to beef systems. 04/10/16
12. Crosson, P., Woods, A. and Keane. J. Beef 2016 (Grange Open Day Book). Suckler beef systems - assessing steps to improve profitability. 05/07/2016
13. Prendiville, E. AHDB, UK. Dairy calf to beef production systems. 27/06/17
14. Prendiville, E. AHDB, UK. Dairy calf to beef production systems. 28/06/17
15. Prendiville, R. Visitors to Teagasc, Wexford. Dairy calf to beef production systems. Various
16. McGee, M., O'Riordan, E. and Moloney, A. Teagasc National Beef Conference. Concentrate feed ingredients for growing-finishing cattle. 17/10/17
17. McGee, M. FETAC accredited Training Course. Ruminant Nutrition. 01/10/17
18. Regan, M. Glanbia (Gain Animal Nutrition) Beef Finishers Conference. Pasture-based finishing of early- and late-maturing breed suckler bulls. 01/10/17
19. O'Riordan, E., M. McGee, M. and Moloney, A. Grass-based suckler weanling-to-beef production systems. In: BEEF 2018, 'Enhancing Knowledge', Tuesday, 26th June 2018, Teagasc, Grange, Dunsany, Co. Meath.

20. Moloney, A.P., McGee, M., O'Riordan, E.G, O'Sullivan, M. and Kerry, J.P. On-farm influences on the eating quality of beef. In: BEEF 2018, 'Enhancing Knowledge', Tuesday, 26th June 2018, Teagasc, Grange, Dunsany, Co. Meath.

(v) Intellectual Property applications/licences/patents

No intellectual property has arisen from the project.

(vi) Other

N/A

5. Scientists trained by Project

Total Number of PhD theses: 4

- Brian Murphy (UCD). The effects of production system and finishing strategy on male calves from the dairy herd (Submitted 2017)
- Sibhehiso Siphambili (UCD). An evaluation of the colour, texture and biochemical characteristics of muscle from suckler bulls finished under various modified pasture-based production systems (Submitted 2018).
- Natasha Ferguson (UCD). Novel dietary strategies to manipulate the carcass composition of dairy bred bull under a pasture based production system (anticipated submission, October 2020).
- Shannon Wilson (UCC). Working title: Sensory characteristics of suckler and dairy origin bull beef (anticipated submission, July 2020).

Total Number of Masters theses: 2

- Ciaran Lenehan (UCD.) Strategies for growing and finishing suckler-bred male cattle prior to a second winter at pasture, or indoors on rations differing in composition (Submitted 2016)
- Maeve Regan (UCD). Grass-based production systems for suckler-bred male cattle (Submitted 2018)

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
Teagasc	13	7.93
UCD	2	2.00
UCC	1	0.25
ICBF	2	0.05
Total	18	10.48

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates/Contract Researchers	2	4.29
PhD students	4	15.43
Masters students	2	3.48
Temporary researchers	2	1.00
Other		
Total	10	24.2

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
Dr Lara Moran	Hot topics in the Agri-Food Sector, 11-13 June 2014
Dr Lara Moran	Innovation in the Bioeconomy, 12-14 November 2014
Dr Lara Moran	Leadership in the Agri-Food Sector, 21-23 January 2015

9. Project Expenditure

Total expenditure of the project: €1,257,551.33

Total Award by DAFM: €1,328,700.70

Other sources of funding including benefit in kind and/or cash contribution(specify):

Teagasc Walsh Fellowship (Ref: 2012054) €81,000

Breakdown of Total Expenditure

Category	Institution 1 Teagasc	Institution 2 UCD	Institution 3 UCC	Institution 4 ICBF	Total
Contract staff			32943.00		32943.00
Temporary staff		1274.43			1274.43
Post doctorates	151999.19		45580.00		197579.19
Post graduates	175750.00	170586.71	83929.00		430265.71
Consumables	210905.77	15225.25	16163.60		242294.62
Travel and subsistence	28775.51	4548.37	9780.50	258.40	43362.78
Sub total	567430.47	191634.76	188396.10	258.40	947719.73
Durable equipment	6294.67	804.42			7099.09
Other	35781.10				35781.10
Overheads	170229.14	57490.43	39153.32	77.52	266951.41
Total	779735.38	249929.61	227550.42	335.92	1257551.33

10. Leveraging

A Teagasc Walsh Fellowship was awarded to fund the PhD work of Kevin McMenamin (award number 2012054) associated with the suckler bull production dimension of the project. To accelerate the progress of the project, an early task in the suckler bull production phase was facilitated by modification of an existing project. The associated costs incurred were borne by Teagasc. Generation of beef samples within this project

allowed linkage with a project within "Sensory Network Ireland" funded by Department of Agriculture Food and the Marine (FIRM: 13SN401), thereby adding value to both projects.

11. Future Strategies

The results of the research have been extensively disseminated through stakeholder engagement, Teagasc Open Days, publications in the popular press, conference presentations and peer reviewed publications as outlined in section 4b. Further work should focus on the relationship between current market specifications for bulls, in particular, age at slaughter and carcass fat classification, and the nutritional value and eating quality of bull beef. Moreover, research on understanding consumer sentiment towards bull beef, particularly grass-fed bull beef, in international markets for Irish beef is warranted.

12. Consent to Publish Final Report on the DAFM Website and/or Through Other Dissemination channels

I consent to this report being made available to the public, through the Department's website and other dissemination channels.

Yes No

13. Declaration

I declare that the information contained in this final report is complete and true to the best of my knowledge and belief.

Signed:  Project Coordinator

Date: April 23, 2020