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

13F411- Science based 'intelligent'/functional and medical foods for optimum brain health, targeting depression and cognition

Final Report

This project was funded under the Department of Agriculture, Food and the Marine Competitive Funding Programme.

SUMMARY

This project aimed to investigate the potential of marine-algal-derived omega-3 polyunsaturated fatty acids (PUFA) and marine polyphenols as dietary ingredients with efficacy to enhance mental health and cognition. This project involved in vitro and in vivo preclinical studies to determine the role of omega-3 PUFA and phytochemicals of marine origin in mood regulation. We used a combination of omega-3 PUFA and sea polyphenols exhibiting antioxidant activity, as a nutritional supplement strategy in an animal model of depression and did studies to unravel the biological mechanisms. The results of this project provide data for development of functional food ingredients for prevention of depression, and medical foods to increase the potency of conventional antidepressants drugs.

KEYWORDS

functional foods, gut-brain axis, polyunsaturated fatty acids

ACRONYM	SMART FOOD
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Section 1 - Research Approach & Results

Start Date

01 December 2013

End Date

31 August 2018

Research Programme

Food Institutional Research Measure

TRL Scale

TRL 1: Basic Principles Observed

NRPE Priority area

Food for Health

Total DAFM Award

€595,846.00

Total Project Expenditure

€561,853.29

Rationale for undertaking the Research

Worldwide incidence of depression is increasing substantially and is predicted to be the second leading cause of disability by 2020 (WHO). Novel strategies, both social and biological, to prevent depression are urgently needed. Recent preclinical and some clinical data suggest that nutrition may reduce depressive symptoms and alleviate cognitive decline, but scientific substantiation of efficacious dietary components is required. The overall aim of this project was to investigate the potential of a combination of omega-3 PUFA and sea polyphenols with known antioxidant activity as nutritional supplement strategies with efficacy to enhance mental health and cognition.

Methodology

Methodology was developed and species identified, for production of microalgal biomass rich in omega-3 fatty acids. Protocols were designed to produce sufficient volume of low molecular weight phorotannin extract from Irish seaweed (Fucus vesiculosus), and bioactivity assessed and supplied by NUI Galway to Teagasc/UCC for testing on animal models of depression. The effects of microalgae-derived omega-3 fatty acids and polyphenols on primary neuronal culture from the cortices of P1 pups and established human cell lines (SH-SY5Y neuronal cell line) were assessed. All experiments were approved by the Ethics Committee of University College Cork, licenced by HPRA, Ireland and in full accordance with the European Community Council Directive (2010/EU/63).

Project Results

Conditions were optimised and species identified, for production of microalgal biomass rich in omega-3 fatty acids. Protocols were designed to produce sufficient volume of low molecular weight phlorotannin extract from Irish seaweed (Fucus vesiculosus), and bioactivity assessed and supplied by NUI Galway to Teagasc/UCC for testing form product development and on animal models of depression. Protocols for production of stable omega 3/polyphenol rich food ingredients from microalga/macroalgae sources for incorporation into food

products are available. Fortified yoghurt and spray dried ingredients were successfully developed enriched in omega-3 fatty acids and extracts from Irish seaweed.

We assessed the effects of microalgae-derived omega-3 fatty acids and polyphenols on primary neuronal culture from the cortices of P1 pups and established human cell lines (SH-SY5Y neuronal cell line). This work confirmed the impact of omega-3 marine lipids and neuroprotective effect of 10 polyphenols on neuronal cell lines. Studies were conducted that demonstrated the impact of dietary intervention with marine omega-3 fatty acids and sea polyphenols as functional foods for prevention of depression in maternally separated animals.

Studies were conducted that demonstrated the impact of dietary intervention with marine omega-3 fatty acids and sea polyphenols as functional foods for prevention of depression in maternally separated rodent animals. Animal studies (rodents) also revealed the impact of microalgae-derived omega 3 fatty acids and macro-algae-derived polyphenols as medical foods in combination with conventional antidepressants for treatment of depression. While fish oil and fluoxetine treatment resulted in significant manipulation of important neurobiological markers, only the changes in the fluoxetine treated animals translated to significant behavioural differences, representing a reduction in a depressive or anxious state.

The findings from this study demonstrated the potential of a combination of omega-3 PUFA and sea polyphenols with known antioxidant activity as nutritional supplement strategies with efficacy to enhance mental health and avoid depression.

Section 2 - Research Outputs

Summary of Project Findings

Cognitive health foods are identified as a major opportunity for the food industry, and this project has generated novel scientific information on the health benefits of marine Ingredients for brain health and their stable incorporation into functional/medical foods. The information generated in this project will provide Ingredient suppliers and the Health Professionals with essential knowledge relating to the impact of nutrition on depression. This work is relevant to the food industry for development of functional and medical foods enriched in omega 3/polyphenols.

Summary of Staff Outputs

Research Output	Male	Female	Total Number
PhD Students	1	1	2
MSc Students	0	1	1
Post Doctorates	1	1	2

Summary of Academic Outputs

Research	Total Number	Details
Masters Theses	1	Clara Seira Oriach, thesis title "In vitro and in vivo preclinical studies to determine the role of omega-3 PUFA and phytochemicals of marine origin in mood regulation, inflammation and microbiota"
PhD Theses	2	1. Francisco Donoso, thesis title "The neurobiological effects of naturally-derived polyphenols and phospholipids in cellular & animal models of stress" 2. Ruairi Robertson, thesis title "Omega-3 fatty acids, gut microbiota and associated inflammatory outcomes"
Publications in Peer Reviewed Scientific Journals	16	1. Moroney NC, O'Grady MN, Robertson RC, Stanton C, O'Doherty JV, Kerry JP. Influence of level and duration of feeding polysaccharide (laminarin and fucoidan) extracts from brown seaweed (Laminaria digitata) on quality indices of fresh pork. Meat science. 2015 Jan 1; 99:132-41. 2. Robertson RC, Guihéneuf F, Bahar B, Schmid M, Stengel DB, Fitzgerald GF, Ross RP, Stanton C. The anti-inflammatory effect of algae-derived lipid extracts on lipopolysaccharide (LPS)-stimulated human THP-1 macrophages. Marine Drugs. 2015 Aug;13(8):5402-24. 3. Pusceddu MM, Nolan YM, Green HF, Robertson RC, Stanton C, Kelly P, Cryan JF, Dinan TG. The Omega-3 polyunsaturated fatty acid docosahexaenoic acid (DHA) reverses corticosterone-induced changes in cortical neurons. International Journal of Neuropsychopharmacology. 2016 Jun 1;19(6): pyv130.

4. Pusceddu MM, El Aidy S, Crispie F, O'Sullivan O, Cotter P, Stanton C, Kelly P, Cryan JF, Dinan TG. N-3 polyunsaturated fatty acids (PUFAs) reverse the impact of early-life stress on the gut microbiota. PloS one. 2015 Oct 1;10(10): e0139721.
5. Robertson RC, Oriach CS, Murphy K, Moloney GM, Cryan JF, Dinan TG, Ross RP, Stanton C. Omega-3 polyunsaturated fatty acids critically regulate behaviour and gut microbiota development in adolescence and adulthood. Brain, behaviour, and immunity. 2017 Jan 1; 59:21-37.
6. Oriach CS, Robertson RC, Stanton C, Cryan JF, Dinan TG. Food for thought: Therole of nutrition in the microbiota-gut–brain axis. Clinical Nutrition Experimental. 2016 Apr 1; 6:25-38.
7. Robertson RC, Mateo MR, O'Grady MN, Guihéneuf F, Stengel DB, Ross RP, Fitzgerald GF, Kerry JP, Stanton C. An assessment of the techno-functional and sensory properties of yoghurt fortified with a lipid extract from the microalga Pavlova lutheri. Innovative Food Science & Emerging Technologies. 2016 Oct 1; 37:237-46.
8. Luczynski P, McVey Neufeld KA, Oriach CS, Clarke G, Dinan TG, Cryan JF. Growing up in a bubble: using germ-free animals to assess the influence of the gut microbiota on brain and behaviour. International Journal of Neuropsychopharmacology. 2016 Aug 1;19(8).
9. Kirke DA, Smyth TJ, Rai DK, Kenny O, Stengel DB. The chemical and antioxidant stability of isolated low molecular weight phlorotannin's. Food chemistry. 2017 Apr 15; 221:1104-12.
10. Gite S, Ross RP, Kirke D, Guihéneuf F, Aussant J, Stengel DB, Dinan TG, Cryan JF, Stanton C. Nutraceuticals to promote neuronal plasticity in response to corticosterone-induced stress in human neuroblastoma cells. Nutritional neuroscience. 2019 Aug 3;22(8):551-68.
11. Codagnone MG, Spichak S, O'Mahony SM, O'Leary OF, Clarke G, Stanton C, Dinan TG, Cryan JF. Programming bugs: microbiota and the developmental origins of brain health and disease. Biological psychiatry. 2019 Jan 15;85(2):15063.
12. van de Wouw M, Boehme M, Lyte JM, Wiley N, Strain C, O'Sullivan O, Clarke G, Stanton C, Dinan TG, Cryan JF. Short-chain fatty acids: microbial metabolites that alleviate stress-induced brain–gut axis alterations. The Journal of physiology. 2018 Oct;596(20):4923-44.
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14. Donoso F, Egerton S, Bastiaanssen TF, Fitzgerald P, Gite S, Fouhy F, Ross RP, Stanton C, Dinan TG, Cryan JF. Polyphenols selectively reverse early life stress induced behavioural,

		neurochemical and microbiota changes in the rat. Psychoneuroendocrinology. 2020 Jun 1; 116:104673. 15. Egerton S, Donoso F, Fitzgerald P, Gite S, Fouhy F, Whooley J, Dinan TG,Cryan JF, Culloty SC, Ross RP, Stanton C. Investigating the potential of fish oil as a nutraceutical in an animal model of early life stress. Nutritional Neuroscience. 2020 Jul 25:1-23. 16. Donoso F, Ramírez VT, Golubeva AV, Moloney GM, Stanton C, Dinan TG, Cryan JF. Naturally derived polyphenols protect against corticosterone-induced changes in primary cortical neurons. International Journal of Neuropsychopharmacology. 2019 Dec;22(12):765-77.
Peer Reviewed Conference Papers	32	1. Ruairi Robertson - 'An investigation into the modulation of the gut microbiota following in vitro fermentation of a seaweed polyphenol extract' – 8th World Congress on Polyphenol Applications, Lisbon, Portugal (June 2014) – Poster presentation. 2. Guihéneuf, F. and Stengel, D.B. LC-PUFA-enriched oil production by the marine haptophyte Pavlova lutheri: combined effects of light, temperature, and inorganic carbon availability. 5th Congress of the International Society for Applied Phycology, 22-27 June 2014, Sydney, Australia (Oral). 3. Guihéneuf, F. and Stengel, D.B. Culture Strategies to Enhance the Potential of Microalgae as a Source of Bioactives for "Healthy" Foods. Natural Product Biotechnology 2014, 18-20 November 2014, Inverness, Scotland (Poster) 4. Kirke, D., Smyth, T., Rai, D. and Stengel, D.B. Optimisation of phlorotannin enriched food products from commercially valuable Irish seaweeds. Natural Product Biotechnology 2014. 18-20 November 2014, Inverness, Scotland (Poster). 5. Aussant, J., Guiheneuf, F., and Stengel, D.B. Microalgae as a source of omega3 fatty acids for mental health food applications. ESAI's Environ 25: Sustainability and Opportunities for Change. IT Sligo, Sligo. 8-10th April 2015 (Poster). 6. Aussant, J., Guiheneuf, F., and Stengel, D.B. Microalgae as a source of omega3 PUFA for mental health food applications. NutraMara Conference 2015: Harnessing Marine Bioresources for Innovations in the Food Industry. Royal Dublin Society, Dublin, Ireland. 29-30th June 2015 (Poster). 7. Aussant, J., Guiheneuf, F., and Stengel, D.B. Microalgae as a source of omega-3 fatty acids for mental health food applications. 6th European Phycological Congress (EPC6) London, England. 23-28th August 2015 (Poster). 8. Clara Seira Oriach. Psychiatry Department, UCC. Micro algal Omega-3 polyunsaturated fatty acids (PUFAs) effects on cognition, sociability, depressive like behaviour and brain fatty acid composition in C57BL/6 mice. Neuroscience Ireland Conference, Sept-2015. Dublin, Ireland. Poster presentation.

9. Kirke, D.A, Rai, D.K., Smyth, T.J and Stengel, D.B. The natural variation of phlorotannin profiles in Irish commercially valuable brown seaweeds. 22nd International Seaweed Symposium (ISS). 19th – 24th June 2016. Copenhagen, Denmark.
10. Aussant, J. and Stengel, D.B. Microalgae as a source of omega-3 fatty acidsfor mental health food applications. 6th European Phycological Congress (EPC6), 23-28 August 2015, London (poster).
11. Aussant, J. and Stengel, D.B. Effect of abiotic factors on selected microalgae for omega-3 PUFA production. 6th ISAP Congress of International Society for Applied Phycology, La cite, Nantes, France, 18-23 June 2017 (Oral presentation)
12. Aussant, J. and Stengel, D.B. Effect of environmental factors on selected microalgae strains for EPA and DHA production. 11th International Phycological Congress, Szczecin, Poland, 13-19th August 2017 (Oral presentation)
13. Kirke, D.A, Rai, D.K, Smyth, T.J and Stengel D.B. Single and interactive effects of PAR and UV on low molecular weight phlorotannin profiles in Fucus vesiculosus using mass spectrometry. 6th ISAP Congress of International Society for Applied Phycology, La cite, Nantes, France, 18-23 June 2017 (Oral presentation).
14. Stengel D.B. Bioactives from marine algae – overview of some research activities at NUI Galway. 18-20 November Inverness, Scotland, oral presentation at Natural Product Biotechnology Inverness, UK, November 2014
15. Stengel D.B. Variability in algal bioactives - the good, the bad and the unknown International Society of Applied Phycology, Sydney, invited symposium oral presentation, June 2014.
16. Dagmar Stengel, NUI Galway. Application of marine algae in food and health- recent developments and remaining challenges. NutraMara Conference, June-29, 2015.
17. Stengel, D. B. (2015). Bridging the gap between algal ecology and biotechnology – more than just learning a new language. 6th European Phycological Congress (EPC6) London, oral presentation.
18. Catherine Stanton. Teagasc Food Research Centre, Moorepark, Marine ingredients for improved brain and gut functioning. NutraMara Conference, June-29, 2015 (Oral presentation).
19. Ruairi Robertson. Micro algal omega-3 supplementation during early life impacts learning, anxiety, social behaviour, and brain fatty acid composition in C57BL/6 mice. NutraMara Conference, June-29, 2015, poster
20. Clara Seira Oriach. Micro algal Omega-3 polyunsaturated fatty acids (PUFAs) effects on cognition, sociability, depressive-like behaviour and brain fatty acid composition in C57BL/6 mice. New Horizons–Translational Research Conference. December-10 2015. Cork, Ireland (Oral presentation).

21. Catherine Stanton: Omega 3 Polyunsaturated Fatty Acids and the Gut Microbiota, Invited speaker at International Conference on Omega-3 and Human Health, Shanghai, China, May 23-24, 2016.
22. Catherine Stanton: Health Implications of Microbial Metabolites Produced by Gut Microbes and implication of Dietary fatty acids. Keynote speech, V International Symposium on Lactic Acid Bacteria Benefitting from Lactic Acid Bacteria. Progress in Health and Food, San Miguel de Tucumán, ARGENTINA, October 19-21, 2016.
23. Aussant, J. and Stengel, D.B. Microalgae as an alternative renewable source of omega-3 PUFA for mental health food applications. 44th Annual Food Research Conference, Teagasc Food Research Centre Moorepark, Fermoy Co. Cork, 14 December 2015 (poster).
24. Kirke, D.A, Rai, D.K, Smyth, T.J, Stengel, D.B. The effect of storage conditions on the stability of low molecular weight phlorotannin's; potential natural food preservatives. International Union of Food Science and Technology (IuFoST). 2125th August 2016. Royal Dublin Society (RDS), Dublin 4, Ireland.
25. Aussant, J. and Stengel, D.B. Effect of abiotic factors on selected microalgae for omega-3 PUFA production. 6th ISAP Congress of International Society for Applied Phycology, La cite, Nantes, France, 18-23 June 2017 (Oral presentation).
26. Aussant, J. and Stengel, D.B. Effect of environmental factors on selected microalgae strains for EPA and DHA production. 11th International Phycological Congress, Szczecin, Poland, 13-19th August 2017 (Oral presentation).
27. Kirke, D.A, Rai, D.K, Smyth, T.J and Stengel D.B. Single and interactive effects of PAR and UV on low molecular weight phlorotannin profiles in Fucus vesiculosus using mass spectrometry. 6th ISAP Congress of International Society for Applied Phycology, La cite, Nantes, France, 18-23 June 2017 (Oral presentation).
28. Stanton, C. Microbial metabolite production by gut microbiomes and implications for host health. FEMS Conference, Valencia, Spain, July, 2017 (Oral presentation)
29. Stanton, C. Infant Gut Microbiota; Implications for host health. Conference on Probiotics, Prebiotics and New Foods, Rome, September 11, 2017 (Oral presentation).
30. Stanton, C. Microbiome, Metabolites and Health. Swisse Symposium, Sydney Australia, April 27th, 2018 (Oral presentation).
31. Stanton, C. Infant Gut Microbiota. Probiota Americas, Florida, USA, June 6th, 2018 (Oral Presentation).

	32. Stanton, C. Microbiota, Metabolites and Host Health. American Society of Microbiology (ASM) Microbes, Atlanta, Georgia, USA, June 8th, 2018 (Oral Presentation).

Potential Impact related to Policy, Practice and Other Impacts

Impact	Details
Other	The overall aim of this project was to investigate the potential of a combination of omega-3 PUFA and sea polyphenols with known antioxidant activity as nutritional supplement strategies with efficacy to enhance mental health and cognition. Within Task 6 'Dissemination' through 11 conference abstracts, 16 peer reviewed publication, internal and external meetings, and 32 conference presentations both national and internationally, the project has succeeded in reaching as wide an audience as possible. The results achieved will be advantageous and of interest to the food industry, in particular marine based, to policy makers within the Irish seafood industry to help valorise this natural resource, to the research community in that it adds to the ever-increasing library of knowledge in the area of cognitive health foods and to the general public as the general demand and understanding of the benefits of these products is continually highlighted.

Dissemination Activities

Activity	Details
Seminars at which results were presented	1. Ruairi Robertson – 'Polyphenol-probiotic interactions' – Science For All University College Cork (April 2014)– Public Science Engagement Event Talk 2. Ruairi Robertson – 'From Belly to Brain' – Fame Lab Ireland (April 2014)– Public Science Engagement Event Talk 3. Ruairi Robertson – 'From Belly to Brain' – Pint of Science Dublin (May 2014)– Public Science Engagement Event Talk 4. Ruairi Robertson – 'The anti-inflammatory effect of algae-derived lipid fractions in THP-1 macrophages' College of Medicine and Health UCC Research Day, Best Speaker Food and Medicine, Michael C. Berndt Gold Medal Winner (June 2014) 5. Ruairi Robertson – 'Seaweed, bellies and brains' – Dalkey Book Festival (June 2014) - Science Public Engagement Event Talk 6. Ruairi Robertson – 'From Belly to Brain' – Future Lab, Festival of Curiosity Talk (July 2014) 7. Ruairi Robertson – 'From Belly to Brain' – Thesis in 3 (October 2014)– Public Science Engagement Event Talk 8. Ruairi Robertson – 'From Belly to Brain' – Celebrate Science Festival UCC (November 2014) – Public Science Engagement Event Talk 9. Ruairi Robertson – 'From Belly to Brain' – Midlands Science Festival (November 2014) – Public Science Engagement Event Talk

	10. Ruairi Robertson – 'From Belly to Brain' – Science Week Tyndall Institute Open Night (November 2014) – Public Science Engagement Event Talk. 11. Ruairi Robertson - An investigation into the modulation of the gut microbiota following in vitro fermentation of a seaweed polyphenol extract' - UCC and Imperial College London Joint Postgraduate Symposium in Food and Health (September 2014) – Poster and Oral presentation. 12. Ruairi Robertson – 'The anti-inflammatory effect of algae-derived lipid fractions in THP-1 macrophages' – New York Academy of Sciences Journey Through Science Day (New York December 2014) – Poster Presentation 13. Aussant, J., Guiheneuf, F., and Stengel, D.B. Microalgae as an alternative renewable source of omega-3 fatty acids. NUIG/UL Research Day. NUI Galway, Galway, Ireland. 21ST April 2015 (Oral Thesis presentation in Science Parallel Session). 14. Aussant, J., Guiheneuf, F., and Stengel, D.B. Microalgae as a source of omega-3 fatty acids for mental health food applications. Ryan Institute Research and Open day NUI Galway, Galway, Ireland. 25th September 2015 (Poster). 15. Clara Seira Oriach. Micro algal Omega-3 polyunsaturated fatty acids (PUFAs) effects on cognition, sociability, depressive-like behaviour and brain fatty acid composition in C57BL/6 mice. Mining Microbes for Mankind. APC-ICL Postgraduate Symposium. October-01, 2015. Cork, Ireland (Oral presentation). 16. Aussant, J. and Stengel, D.B. Effect of temperature on selected microalgae omega-3 PUFA production. 6TH postgraduate Research Day, University of Limerick, April 29th, 2016 (poster).
Media Events	1. Ruairi Robertson – 'Seaweed Diet Could Stave off Illness' – Evening Echo Newspaper (July 2014). 2. Clara Seira Oriach- 'Why are blueberries a 'superfood'? - Irish Independent newspaper (June 2015).
Workshops at which results were presented	1. Snehal Gite, Justine Aussant, Dara Kirke, Dagmar Stengel, Paul Ross and Catherine Stanton. Neuroprotective effect of some macro and micro algal extracts. Marine Institute Sea Change Researchers Workshop at Galway, June 30, 2016, (Oral presentation).
Other	1. Ruairi Robertson – 'An investigation into the modulation of the gut microbiota following in vitro fermentation of a seaweed polyphenol extract' – Alimentary Pharmabiotic Centre Scientific Advisory Board Day, October 2014 (Poster presentation)

Knowledge Transfer Activities

Identify knowledge outputs generated during this project.	Cognitive health foods are identified as a major opportunity for the food industry, and the key knowledge outputs that were generated by the project included novel scientific information on the health benefits of marine Ingredients for brain health and their stable incorporation into functional/medical foods. The information generated in this project provides ingredient suppliers and health professionals with essential knowledge relating to the impact of nutrition on depression.
Identify any knowledge transfer activities executed within the project.	There were many key knowledge transfer activities that occurred during this project in which the key knowledge outputs were passed onto potential next or end users. These included publications in peer reviewed papers, oral and poster presentations at conferences, a workshop, several meetings, press publications, seminars and talks at several public science engagement events. Therefore, this knowledge is now available to the general public, scientists, health professionals and food industry.
List any impacts resulting from the knowledge transferred during the project.	The project has resulted in the training of scientists, 2 PhD and 1 MSc who have now entered the research community. Ruairi Robertson in particular was awarded a Fulbright Scholar to Harvard Medical School and is undertaking a Sir Henry Wellcome Postdoctoral Fellowship at Queen Mary University of London. He is a prolific science communicator and has his own podcast series on microbiome research, BIOMES. The outputs of the projects were used to leverage funding for EU7P7 MyNewGut(2013-2018), APC3 SFI FUNDS(2013-2018) and Hydrofish Disruptive Technologies Innovation Fund.

Section 3 – Leveraging, Future Strategies & Reference

Leveraging Metrics

Type of Funding	Funding €	Summary
Exchequer National Funding	€340,188.70	Hydrofish: Developing fish hydrolysate technologies to target critical life stages in fish farming. The benefits of conferring functional properties of the hydrolysate to the farmed fish will break the reliance of pharmaceutical compounds and change farming practices, e.g., priming the fish immune system during the early life stage and reduce fish stress
EU R&I programmes	€8,900,000.00	EU7P7 MyNewGut (2013-2018). A multidisciplinary project funded by the European Union's Seventh Framework Programme to contribute to prevent diet-related diseases and behavioural disorders through lifestyle changes and microbiome based dietary recommendations.
Exchequer National Funding	€6,750,000.00	APC3 SFI FUNDS (2013-2018). APC Microbiome Ireland SFI Research Centre, explored the role that microbes (microbiome) play in health and disease.

Future Strategies

Cognitive health foods are identified as a major opportunity for the food industry. Our in vitro and in vivo preclinical studies generated novel scientific information on the health benefits of marine ingredients for brain health and their stable incorporation into functional/medical foods. Following on from these successful in vitro and in vivo preclinical studies, projects are currently being proposed to continue to human intervention studies with polyphenols for cognitive health.

Project Publications

1. Moroney NC, O'Grady MN, Robertson RC, Stanton C, O'Doherty JV, Kerry JP. Influence of level and duration of feeding polysaccharide (laminarin and fucoidan) extracts from brown seaweed (Laminaria digitata) on quality indices of fresh pork. Meat science. 2015 Jan 1; 99:132-41.
2. Robertson RC, Guihéneuf F, Bahar B, Schmid M, Stengel DB, Fitzgerald GF, Ross RP, Stanton C. The anti-inflammatory effect of algae derived lipid extracts on lipopolysaccharide (LPS)-stimulated human THP-1 macrophages. Marine Drugs. 2015 Aug;13(8):5402-24.
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6. Robertson R, Guihéneuf F, Schmid M, Stengel DB, Fitzgerald G, Ross P, Stanton C. Algae-derived polyunsaturated fatty acids: implications for human health. Polyunsaturated fatty acids: sources, antioxidant properties and health benefits. 2013:45-99.

7. Oriach CS, Robertson RC, Stanton C, Cryan JF, Dinan TG. Food for thought: The role of nutrition in the microbiota-gut–brain axis. Clinical Nutrition Experimental. 2016 Apr 1; 6:25-38.
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16. Donoso F, Ramírez VT, Golubeva AV, Moloney GM, Stanton C, Dinan TG, Cryan JF. Naturally derived polyphenols protect against corticosterone-induced changes in primary cortical neurons. International Journal of Neuropsychopharmacology. 2019 Dec; 22(12):765-77.