



# 15F737 - Innovative food structures to enhance the sensory experience, the nutrient profile and nutrient bioavailability for older people.

## Final Report

## **SUMMARY**

Nutriplus sought to develop innovative foods for global elderly populations. The project aimed to develop foods that are easy to chew, digest and promote nutrient bioavailability, particularly Vitamin D in older cohorts.

Results - The project was successful in:

Creating novel foam structures rich in protein and vitamins that are easy to chew and digest;  
Developing nano-emulsions and microemulsions that are easily digested and provide controlled release and improved bioavailability of vitamin D;  
Developing the processing protocols for the manufacture of the fortified emulsions;  
Advancing and developing new sensory science methodology for older cohorts to ensure foods had desirable organoleptic properties and acceptability;  
Established the vitamin D bioavailability of the foods in a human intervention trial in an older cohort and advanced our understanding of vitamin D bioavailability.

Impact

Knowhow for industry to formulate food structures to enhance the bioavailability of vitamin D and the potential for new ingredients in the buoyant global functional food market.  
Potential for added value/increased margins for whey protein in its capacity to protect vitamin D.  
Knowledge gleaned could be used to formulate innovative foods with health benefits.  
Knowledge on formulating and processing stable dairy based nano- and micro-emulsions to pilot level, to enhance the bioavailability of vitamin D and meet the specific nutritional needs of older adults.  
Knowhow to formulate nutritional supplements that will be better liked by an older population. This could enhance compliance and consumption, offsetting conditions associated with malnutrition in the older population including sarcopenia and falls.  
Developed sensory methodology that facilitates rapid but reliable analysis of the sensory perceptions of the older population.  
Publication of a report on the public health impact of improving bioavailability of Vitamin D.  
Five trained postgrads with skills for innovative product development.

## **KEYWORDS**

Vitamin D, Food-fortification, Ageing

## **ACRONYM**

NutriPlus

## **PROJECT COORDINATOR, INSTITUTION**

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## **COLLABORATORS, INSTITUTION**

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Dr Elaine Duggan, Waterford Institute of  
Technology

## **PUBLICATION DATE**

November 2021.

# Section 1 - Research Approach & Results

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## Start Date

01 February 2017

## End Date

30 November 2021

## Research Programme

Food Institutional Research Measure

## TRL Scale

TRL 4: Technology validated in lab

## NRPE Priority area

Food for Health

## Total DAFM Award

€599,950

## Total Project Expenditure

€576,139.97

## Rationale for undertaking the Research

In 2020, the number of people aged 60 years and older outnumbered children younger than 5 years.

Between 2015 and 2050, the proportion of the world's population over 60 years will nearly double from 12% to 22% (WHO 2022). As people age several conditions develop that cause poor health. In the mouth, weakened teeth/gums and muscle dysmotility make chewing food unpleasant and unsuccessful. In the stomach/intestine decreased secretions (acid, pepsin) reduce digestive capability leading to immunocompromised adults. The national adult nutrition survey (2011) highlighted that over 65's were below the estimated daily requirement by 85% for vitamin D, 37% for magnesium while the HSE (2008) reported that diseases of the digestive system cost the HSE 333,716 hospital bed-days. This project sought to develop food structures that are easily digested providing a readily available source of vitamin D for an elderly cohort. The emulsion based foods were designed to improve general health among over 65's and the foams targeted later lifestage adults suffering from oral processing difficulties.

The global functional foods market size was estimated at \$280.7 billion in 2021 and is expected to expand at a compound annual growth rate of 8.5% from 2022 to 2030. There is a rising demand for nutritional and fortified foods but there is a lack of satisfactory foods designed specifically for older people. The research will support Irish industry compete for this business. Furthermore the foods designed were based on milk proteins and designed to add value to Ireland's dairy ingredients to global markets.

## Methodology

Microgel particles were manufactured by injecting heat-treated whey protein solutions into CaCl<sub>2</sub>. Vitamin D was dissolved in ethanol and added to the pre-heated whey protein before addition of CaCl<sub>2</sub>. Gels were characterised using scanning electron microscopy.

Food protein solutions were subjected to mechanical whipping to produce foams which were assessed for foam volume, overrun and drainage over time.

Laboratory scale nano-emulsions were prepared using a range of fatty acids (C8-C18) and phospholipid concentrations. Optimized formulations were used to entrap vitamin D.

Pilot scale emulsions were prepared using a microthermics heat exchanger with in-line homogenisation. A Y-chamber using pressures up to 1700 bar was used for the nano-emulsions and pressures of 130 bar 1st stage and 35 bar second stage were used to create the micro-emulsion in a homogeniser. The dried emulsions were characterised using raman confocal laser microscopy and dynamic microscopy.

Surface tension, viscosity, particle size of the nano and micro emulsions were measured.

The INFOGEST 2.0 simulated gastrointestinal digestion model was used to assess in-vitro digestibility of the structures and vitamin D bioavailability post digestion was detected by HPLC.

Check-All-That-Apply and Temporal Dominance Techniques were the methods used for sensory analysis with panels of 80 older people.

For the postprandial human study, a cross-over placebo control was conducted. Participants were cannulated by a trained phlebotomist and a baseline serum was collected and 25OHD measured at 2, 4, 6 and 8 hours.

For the human intervention trial, 77 volunteers were recruited and consumed one of the following treatments daily for 4 weeks: a vitamin D3 fortified olive oil based drink, a vitamin D3 fortified coconut oil based drink, a vitamin D3 supplement or a placebo drink. Serum samples were collected at baseline and after 4 weeks to measure 25(OH)D concentration and other biochemical measures.

## **Project Results**

Developed a range of protein-based calorie dense foams that could be easily swallowed and digested by older cohorts. Ultra-stable foams with stability of >2years were developed using whey protein microgels. The microgels also enhanced the stability of vitamin D. The stable foams have potential to become functional foods.

Developed nano- and micro-scale emulsions to protect vitamin D in food environments and enhance vitamin D bioavailability.

Increased our understanding of how structures that enhance absorption of Vitamin D are produced during food digestion and gained insight as to how lipid containing foods should be formulated to enhance vitamin D bio-accessibility and bioavailability and the role of non dairy polymers. Dairy protein emulsions were manufactured in a pilot plant and were stable under normal food processing (heat and shear) and environmental conditions (pH, salts, surfactants). The emulsions protected and stabilised Vitamin D and other fat soluble entities e.g.  $\beta$ -carotene.

The most critical sensory attributes for emulsion based drinks that drive likeability in an older population were established. The project increased our understanding of the impact of ageing and medication on sensory perception of food. New sensory methodology for use in an older cohort for use in their home environment if required, was developed and validated.

Demonstrated that fortifying milk and bread with vitamin D is a safe and effective way to improve vitamin D intakes of older adults (50+ years) in Ireland and should be considered by policy makers to improve vitamin D intakes by older adults.

The human trial showed that daily consumption of vitamin D3 fortified dairy drinks with different lipid compositions match responses from vitamin D3 supplements over a 4-week period. It showed the presence of lipids in a food impacts absorption of vitamin D3 and the type of lipid also appears to impact response in sub-groups. There was a significant increase in plasma Vitamin D levels in response to all the drinks for participants who had insufficient Vitamin D at the outset. Whereas there was only a significant increase in the coconut oil

drink and supplement groups for those who started the study vitamin D sufficient. This is a critical factor for future study design and in guiding vitamin D food fortification policy.

## Section 2 - Research Outputs

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### Summary of Project Findings

It provides the 'knowhow' for industry to formulate food structures to enhance the bioavailability of vitamin D and the potential to underpin the preparation and launch of new ingredients in the buoyant global functional food market.

Potential for added value/increased margins for whey protein in its capacity to protect vitamin D.

Knowledge gleaned could also be used to formulate innovative foods with health benefits.

Knowledge on formulating and processing stable dairy based nano- and micro-emulsions to pilot level that can enhance the bioavailability of vitamin D and meet the specific nutritional needs of older adults. 'Knowhow' to formulate nutritional supplements that will be better liked by an older population. This could facilitate better compliance and consumption, offsetting conditions associated with malnutrition in older cohorts including sarcopenia, frailty and falls.

Developed sensory methodology that is rapid but reliable for older populations.

Publication of a report on the public health impact of improving bioavailability of Vitamin D in older adults.

This guides policy makers in relation to fortification of food with vitamin D.

Five postgraduates with extensive scientific training in foods with health benefits, data analysis skills and competences in innovative product development.

Showed that the vitamin D status of the older cohorts on commencing the study had a big effect on the efficacy of supplementing diets with vitamin D. There was a significant increase in plasma Vitamin D levels in response to all the drinks, for participants who had insufficient Vitamin D at the outset. Whereas there was only a significant increase in the coconut oil drink and supplement groups for those who started the study vitamin D sufficient. This is a critical factor for future study design and in guiding vitamin D food fortification policy.

### Summary of Staff Outputs

Research Output	Male	Female	Total Number
PhD Students	1	3	4
MSc Students	0	1	1

### Summary of Academic Outputs

Research Outputs	Total Number	Details
Publications in Peer Reviewed Scientific Journals	No Response	1. Regan, E., O'Neill, G.J., Hutchings, S.C. and O'Riordan, D. (2019) "Exploring how age influences sensory perception, Journals thirst and hunger during the

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- consumption of oral nutritional supplements using the check-all-that-apply methodology'. *Food Quality and Preference* DOI:10.1016/j.foodqual.2019.103736.
2. Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D. (2021). *Food Quality and Preference* DOI:10.1016/j.foodqual.2021.104224.
  3. Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D. (2023). 'Factors influencing thirst perception during the consumption of oral nutritional supplements in older adults'. Published in *Food Quality and Preference* DOI: 10.1016/j.foodqual.2022.104719
  4. Regan, E., Feeney, E.L., Schlich, P., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D.(2023). 'Measuring the effectiveness of the temporal dominance of sensations technique to investigate the dynamic perception of oral nutritional supplements by older adults'. Published in *Food Quality and Preference* DOI:10.1016/j.foodqual.2022.104720
  5. Mulrooney, S. L., O'Neill, G. J., Brougham, D. F., & O'Riordan, D. (2021). Vitamin D3 bioaccessibility: Influence of fatty acid chain length, salt concentration and l- $\alpha$ -phosphatidylcholine concentration on mixed micelle formation and delivery of vitamin D3. Published in *Food Chemistry* DOI: 10.1016/j.foodchem.2020.128722
  6. Mulrooney, S. L., O'Neill, G. J., Brougham, D. F., Lyng, J. G., & O'Riordan, D. (2021). Improving vitamin D3 stability to environmental and processing stresses using mixed micelles. Published in *Food Chemistry* DOI: 10.1016/j.foodchem.2021.130114
  7. Mulrooney, S. L., O'Neill, G. J., Brougham, D. F., & O'Riordan, D. (2022). Enhancing the bioaccessibility of vitamin D using mixed micelles – An in vitro study. Published in *Food Chemistry* DOI: 10.1016/j.foodchem.2022.133634
  8. McCourt A, McNulty BA, Walton J, O'Sullivan A. Efficacy and safety of food fortification to improve vitamin D intakes of older adults. *Nutrition*. 2020 Jul-Aug;75-76:110767.
  9. McCourt AF, O'Sullivan AM. Using food fortification to improve vitamin D bioaccessibility and intakes. *Proc Nutr Soc*. 2022 Mar;81(1):99-107
  10. McCourt AF, Mulrooney SL, O'Neill GJ, O'Riordan ED, O'Sullivan AM. Postprandial 25-hydroxyvitamin D response varies according to the lipid composition of a vitamin D3 fortified dairy drink. *Int J Food Sci Nutr*. 2022 May;73(3):396-406
  11. Lee, J., Duggan, E. (2022) Improved stability of vitamin D3 encapsulated in whey protein isolate microgels. *International Dairy Journal*, 129, Article 105351.
  12. Lee, J., Duggan, E. (2022) Whey protein microgels for stabilisation of foams. *International Dairy Journal*, 132, Article 105399.
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4 PhD theses

Emma Regan, PhD thesis Sensory perceptions of oral nutritional supplements by older adults. Thesis submitted to University College Dublin in fulfilment of the requirements for the degree of Doctor of Philosophy. Submitted October 2021. Graduated June 2022.

Aislinn McCourt, PhD thesis: Food fortification to enhance the vitamin D status of older adults. Thesis submitted to University College Dublin in fulfilment of the requirements for the degree of Doctor of Philosophy. Submitted June 2021. Graduated September 2021.

Steven Mulrooney, PhD thesis: Food emulsions: their role in enhancing the stability and bioavailability of vitamin D. Thesis submitted to University College Dublin in fulfilment of the requirements for the degree of Doctor of Philosophy. Submitted September, 2021. Graduated June 2022.

Jenna Lee, PhD thesis: Microgels and foams to enhance the bioavailability of Vitamin D. Submitted 2022.

PhD Theses

No Response

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Masters Theses

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Snehal Satish Deshmukh, MSc Thesis UCD : Formulation and processing of dairy-based emulsions for optimal stability and protection of labile micronutrients. Submitted May 2021. Graduated December 2021.

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Peer Reviewed  
Conference Papers

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1. Oral Presentation: Regan, E., O'Neill, G.J., Hutchings, S.C. and O'Riordan, D. (2018). Differences in sensory perception and satiety between younger and older consumers during the consumption of oral nutritional supplements. 7th European Sensory Science Society Symposium, Dublin, Ireland.
  2. Poster Presentation: Regan, E., O'Neill, G.J., Hutchings, S.C. and O'Riordan, D. (2018). Differences in sensory perception and satiety between younger and older consumers during the consumption of oral nutritional supplements. 16th Euro Fed Lipid Congress and Expo, Belfast, United Kingdom.
  3. Oral Presentation: Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, D. (2019). Differences in the dynamic sensory perception of oral nutritional supplements between older and younger adults using the temporal dominance of sensations technique across a range of supplements of different textures. IFSTI: 48th Annual Food Science and Technology Conference, Limerick, Ireland.
  4. Oral Presentation: Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, D. (2020). Exploring the differences in texture perception of oral nutritional
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- supplements between older and younger adults, using the temporal dominance of sensations technique. 34th EFFoST International Conference, Online.
5. Poster Presentation: Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, D. (2020). Exploring the differences in texture perception of oral nutritional supplements between older and younger adults, using the temporal dominance of sensations technique. 34th EFFoST International Conference, Online.
  6. Oral Presentation: Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, D. (2020). Oral nutritional supplements – exploring if older and younger adults perceive their texture differently, using the temporal dominance of sensations technique. EUROSENSE 2020: 9th European Conference on Sensory and Consumer Research, Online.
  7. Poster Presentation: Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, D. (2020). Measuring the effectiveness of the Temporal Dominance of Sensations technique to investigate the differences in the texture perception of Oral Nutritional Supplements between older and younger adults. IFSTI: 49th Annual Food Science and Technology Conference, Online.
  8. Poster Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2018). Optimisation of mixed micelles for vitamin D delivery. 16th Euro Fed Lipid Congress and Expo, Belfast, UK.
  9. Poster Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2018). Optimisation of mixed micelles for vitamin D delivery. IFSTI 47th Annual Food Science and Technology Conference, Cork, Ireland.
  10. Oral Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2019). Formulating mixed micelles to improve vitamin D bioavailability. 6th International Conference on Food Digestion, Granada, Spain.
  11. Poster Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2019). Improving vitamin D bioaccessibility using mixed micelles. IFSTI 48th Annual Food Science and Technology Conference, Limerick, Ireland.
  12. Oral Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2020). Mixed micelles and their potential to enhance vitamin D bioaccessibility. Controlled Release Society Virtual Annual Meeting, Las Vegas, USA (online).
  13. Oral Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2020). Preparation of mixed micelles to protect vitamin D from degradation and improve vitamin D bioaccessibility. 34th EFFoST International Conference, Israel (online).
  14. Poster Mulrooney, S. L., O'Neill, G. J., & O'Riordan, D. (2020). Investigating the potential for mixed micelles to protect vitamin D3 from degradation during food processing and storage. IFSTI 49th Annual Food Science and Technology Conference, Dublin, Ireland (online).
  15. Oral Mulrooney, S. L., O'Neill, G. J., Lyng, J. G., & O'Riordan, D. (2021). Investigating the potential for
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mixed micelles to protect vitamin D3 from degradation during food processing, storage, and digestion.

Controlled Release Society Virtual Annual Meeting (online).

16. Poster Oct 2020 UCD IFH Research Day: Mixed micelles protect vitamin D3 from degradation during food processing and storage Steven L. Mulrooney, Graham J. O'Neill, James G. Lyng, Dolores O'Riordan. Poster presentation.
  17. Oral Nov 2021 McCourt AF, O'Sullivan AM. Using food fortification to improve vitamin D bioaccessibility and intakes. Proc Nutr Soc. 2021 Nov 22:1-9. Oral presentation
  18. Oral June 2021 Irish Postgraduate Competition 2021 – Irish Section Nutrition Society Conference – Online “Altering the fat component of fortified foods increases vitamin D absorption.” McCourt AF, O'Sullivan AM. Oral presentation
  19. Oral Feb 2021 INDI Research Symposium – Online “25(OH)D response to different lipid delivery systems in older adults: A randomised controlled trial” A McCourt, S Mulrooney, Dr G O'Neill, Prof D O'Riordan, Dr A O'Sullivan.
  20. Oral Dec 2020 49th Annual Food Sci & Technology Conference: “25(OH)D response to different lipid delivery systems in older adults: A randomised controlled trial” A McCourt, S Mulrooney, Dr G O'Neill, Prof D O'Riordan, Dr A O'Sullivan Oral presentation
  21. Oral Oct 2020 UCD IFH Research Day: “Vitamin D bioavailability from different lipid delivery systems” A McCourt, S Mulrooney, Dr G O'Neill, Prof D O'Riordan, Dr A O'Sullivan. Oral presentation Dec 2020
  22. Oral Feb 2020 Nutrition Society Postgraduate Conference: “Vitamin D bioavailability from different lipid delivery systems” A McCourt, S Mulrooney, G O'Neill, Prof D O'Riordan, Dr A O'Sullivan. Oral presentation
  23. Oral Oct 2019-13th European Nutrition Conference: “Vitamin D bioavailability from lipid delivery systems”. A McCourt, S Mulrooney, G O'Neill, Prof D O'Riordan, Dr A O'Sullivan Oral presentation
  24. Poster Mar 2019- UCD CHAS Research Conference: “Food solutions to 58 / 63 improve Vitamin D status”. A McCourt, Dr B McNulty, Dr J Walton, Dr A O'Sullivan. Poster presentation
  25. Oral Feb 2019 Nutrition Society Postgraduate Conference: “Food solutions to improve Vitamin D status”. A McCourt, Dr B McNulty, Dr J Walton, Dr A O'Sullivan. Oral presentation
  26. POSTER A McCourt, Dr B McNulty, Dr J Walton, Dr A O'Sullivan. “Food solutions to improve Vitamin D status”. INDI Research Symposium: January 2019.
  27. Oral A McCourt, Breige Mc Nulty, Janette Walton, Aifric O'Sullivan. Food solutions to improve Vitamin D status”.
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November 2018, Irish Postgraduate Research Conference

28. Oral McCourt, Kate Bermingham, Helena Scully, Aifric O'Sullivan "Vitamin D Status of Irish 8-10 Year Olds" June 2018, UCD CHiLD Summer Seminar Series.
29. ORAL A McCourt, Breige McNulty, Janette Walton, Aifric O'Sullivan. " Food solutions to improve Vitamin D status" February 2018, Nutrition Society Postgraduate Conference.
30. Oral A McCourt, Aifric O'Sullivan. "Can we improve Vitamin D Status in Ireland?" December 2017. UCD CHiLD Research Meeting.
31. J. Lee, E. Duggan. 'Whey protein microgels for stabilisation of foams'. 48th Annual Food Science & Technology conference, Limerick, December 2019. Poster presentation. Awarded Best Poster.
32. J. Lee, E. Duggan. 'Encapsulation of vitamin D in whey protein microgels: stability and foaming properties'. 49th Annual Food Science & Technology virtual conference, TU Dublin December 2020. Oral presentation. Awarded Best Oral Presentation.
33. J. Lee, E. Duggan. 'Encapsulation of vitamin D in whey protein microgels: stability and foaming properties'. Waterford Institute of Technology Virtual Postgraduate Conference 2021. Oral presentation.
34. J. Lee, E. Duggan. 'The effect of vitamin D on the foaming properties of whey protein isolate microgels'. 4th Food Structure and Functionality Symposium, Structuring Foods for a Sustainable World virtual conference, Cork, October 2021. Poster presentation.
35. J. Lee, E. Duggan. 'Stability and bioavailability of vitamin D encapsulated in whey protein isolate microgels'. 35th EFFoST International conference 2021, Healthy Individuals, Resilient Communities, and Global Food Security. Lausanne, Switzerland, November 2021. Oral presentation.
36. Poster Snehal Deshmukh, Laura G. Gómez Mascaraque, Sean A Hogan; Niamh Harbourne, Dolores O'Riordan, Mark A. Fenelon. Effect of Thermal Denaturation and Calcium on Interfacial tension of Whey Protein stabilised Emulsions. (2020). 49th. Annual Food Science and Technology Conference: Dec. 15, 2020 hosted by TUD. Poster presentation

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Peer reviewed papers in review

1. McCourt AF, Mulrooney SL, O'Neill GJ, O'Riordan ED, O'Sullivan AM. 25-hydroxyvitamin D response to vitamin D supplementation using different lipid delivery systems in older adults: A randomised controlled trial. Br J Nutr Submitted
2. McCourt AF, O'Sullivan AM. Influence of vitamin D status and supplementation on metabolomic profiles of older adults. Metabolites Submitted

Other

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## Intellectual Property

The project focused on the protection of knowhow rather than IP following discussions with UCD IP specialists in NOVA UCD.

## Summary of other Project Outputs

Project Outputs	Details	Total Number
New Products	The project provided the know-how to formulate: Whey gels to protect Vitamin D. Foam based food - rich in calories but easy to swallow by an older cohort readily digestible. Formulations for nutrient dense micro and nano emulsions to protect vitamin D in food systems and enhance the bioavailability of Vitamin D. The nano-emulsion formulations will allow vitamin D be delivered in aqueous foods which was not possible heretofore. Dairy beverages providing bespoke nutrients for an elderly cohort which are readily digestible, appealing and increase vitamin D bioavailability.	0
New Processes	Pilot scale processes to produce stable dairy based nano-emulsions.	1

## Potential Impact related to Policy, Practice and Other Impacts

Impact	Details
Other	Data from this research was included in a Food Safety Authority of Ireland (FSAI) report on vitamin D from 5-65 year olds, written by the FSAI Public Health Nutrition group.

## Dissemination Activities

Activity	Details
Media Events	Twitter account @NutriPlusUCD - updates re Vitamin D were regularly shared Linked in accounts of researchers where the project was highlighted Key outputs from the project were issued through twitter account @UCDFoodandHealth
Seminars at which results were presented	Public-events 1. O'Sullivan presented an online lecture as part of UCD's Institute of Food and Health public lecture series-21-09 -20. Speaking on sustainable healthy diets she highlighted the role of Vitamin D.

2. O'Riordan participated in a global webinar hosted by the Dairy Reporter in 11-20 and spoke about dairy products as a delivery vehicle to enhance vitamin D status
3. Oct 2019 Age Ireland Over 50's Expo, RDS, Dublin. Vitamin D education presented by A McCourt and Emma Regan.
4. Nov 2019 DAFM Science Week: "NutriPlus Vitamin D Study". Presented by AO'Sullivan
5. Aifric O'Sullivan: National Dairy Council and Irish Nutrition and Dietetics Institute Presentation on "Sustainable diets" Thurs 15th Nov2018. Royal College of Physicians Ireland. The importance of Vit D was referenced.
6. The project has been disseminated through a series of activities at UCD's Institute of Food and Health. This included: A public lecture on nutrition for the older population in January 2019 attended by over 200 people. UCD Public Festival held in the UCD science centre in June 2018 with overall footfall of 10,000 people where rolling presentations were made.
7. J. Lee. 'Foams for elderly nutrition' Waterford PubhD -March 2019.

## Knowledge Transfer Activities

Identify knowledge outputs generated during this project.

Understanding of factors impacting bioavailability of vitamin D in humans both from a food formulation and physiological perspective.

Increased knowledge of factors affecting the sensory perception of older adults including impact of pharmaceuticals, dentition, saliva flow and thirst.

Knowledge of the drivers of liking (taste and texture) of nutritional supplements in older adults.

How to prepare ultrastable foams.

Techniques to help protect vitamin D in food systems.

Formulation and manufacture of stable micro and macroemulsions to increase vitamin D bioavailability.

Analytical techniques to identify micro and macro nutrients in complex foods digested in vitro.

Enhance texture analysis techniques.

Bespoke sensory analysis techniques for older adults.

How best to fortify foods with Vitamin D to get a public health outcome.

Identify any knowledge transfer activities executed within the project.

There were many discussions with industry regarding the formulation of the nutritional beverages used in the human studies. Both Kerry and Carbery inputted

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ingredients to manufacture the drinks based on a sharing of our knowledge on the functionality required.

It is hoped that this exchange of information will be progressed to knowledge transfer if a funding proposal in preparation for EI is funded.

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List any impacts resulting from the knowledge transferred during the project.

Data from this research was included in a Food Safety Authority of Ireland (FSAI) report on vitamin D from 5-65 year olds, written by the FSAI Public Health Nutrition group.

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### Section 3 - Leveraging, Future Strategies & Reference

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#### Leveraging Metrics

Type of Funding Resource	Funding €	Summary
Exchequer National Funding	€1,356,150.02	<p>2021 FIRM DAFM €1,256,295.02. This research contributed to a funded application to the 2021 FIRM DAFM research call entitled “Development of a National Framework for Vitamin D Deficiency Prevention – A Multi-Actor Approach to Nutrition Security”.</p> <p>The IRC provided €32,530 to Emma Regan to build on her DAFM funding to allow her complete a PhD.</p> <p>Mark Fenelon received a Walsh Fellowship valued at €48,000.</p> <p>Steven Mulrooney received a UCD seed fund of €1250 for dissemination.</p> <p>Aifric O'Sullivan was awarded €5000 from the UCD Institute of Food and Health to hold a Vitamin D workshop.</p> <p>All 4 students were delayed in their research due to COVID restrictions. They each availed of a HEA funded stipend of 3-4months as an add on to the stipend funded by DAFM as they had to continue their research when DAFM payment ceased. In addition the Universities waived the fees due for the extended period of study. As co-ordinator, I do not have sight of the total sum received from the HEA as it was paid directly to students from the individual universities. Therefore the monetary value of this support is not included in the total.</p>

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## Future Strategies

The project generated significant knowledge regarding nutrient (both macro and micro) absorption in older cohorts and how ageing influences sensory perception of foods. It also led to formulations for innovative formulations and processes designed to enhance nutrient bioavailability for the elderly and in a food form that is acceptable to them. Significant advances were also made in the analytical techniques to characterise the physical and chemical properties of foods. The PI is currently preparing a proposal as part of a business plan for the next phase (4) of EI funded FHI to advance the research in Nutriplus to commercial outcomes. This will be completed Q2 of 2023. The co-ordinator is travelling to Japan in March 2023 on a Bord Bia led mission. She will highlight the ageing research done in the DAFM project with Japanese companies with whom Irish companies e.g. Kerry, Tiarlán and Carbery have links.

## Project Publications

Peer reviewed papers

1. Regan, E., O'Neill, G.J., Hutchings, S.C. and O'Riordan, D. (2019) 'Exploring how age influences sensory perception, thirst and hunger during the consumption of oral nutritional supplements using the check-all-that-apply methodology'. *Food Quality and Preference* DOI:10.1016/j.foodqual.2019.103736.
2. Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D. (2021). *Food Quality and Preference* DOI:10.1016/j.foodqual.2021.104224.
3. Regan, E., Feeney, E.L., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D. (2023). 'Factors influencing thirst perception during the consumption of oral nutritional supplements in older adults'. Published in *Food Quality and Preference* DOI: 10.1016/j.foodqual.2022.104719.
4. Regan, E., Feeney, E.L., Schlich, P., Hutchings, S.C., O'Neill, G.J. and O'Riordan, E.D. (2023). 'Measuring the effectiveness of the temporal dominance of sensations technique to investigate the dynamic perception of oral nutritional supplements by older adults'. Published in *Food Quality and Preference* DOI: 10.1016/j.foodqual.2022.104720.
5. Mulrooney, S. L., O'Neill, G. J., Brougham, D. F., & O'Riordan, D. (2021). Vitamin D3 bioaccessibility: Influence of fatty acid chain length, salt concentration and l- $\alpha$ -phosphatidylcholine concentration on mixed micelle formation and delivery of vitamin D3. Published in *Food Chemistry* DOI:10.1016/j.foodchem.2020.128722.
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