DPTC PUBLICATIONS

Phase 1 and Phase 2

Acknowledgements

We would like to thank all Principal Investigators, researchers, and industry partners for their collaboration and hard work, which have resulted in these 148 peer-reviewed publications. Your contributions have been essential in advancing the DPTC research agenda.

We appreciate the support from our industry collaborators, which has greatly enhanced our research. To our researchers, your dedication and efforts are the driving force behind our achievements.

This book of abstracts reflects the collective success of our community. Thank you for your ongoing commitment.

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Research Programme: *Phase 1*

Determination of Listeria monocytogenes numbers at less than 10 cfu/g

Hunt K.; Vacelet M.; Jordan K.

Irish Journal of Agricultural and Food Research, 2017

Listeria monocytogenes is a foodborne pathogen that causes a relatively rare foodborne disease called listeriosis, with a high mortality rate of 20%-30% and an undefined dose response. Current European Union regulations permit up to 100 colony-forming units (cfu)/g in food at the end of its shelf life, where the food has been shown not to support the growth of this pathogenic bacterium. Therefore, enumeration of L. monocytogenes at low numbers in food is important. The objective of this study was to reduce the detection limit of L. monocytogenes in food by a factor of 10. The International Organisation for Standardisation (ISO) 11290-2 method for enumeration of L. monocytogenes in food recommends spreading 0.1 mL of a 1:10 dilution of the food on the surface of an agar plate (detection limit 100 cfu/g), or 1.0 mL spread in equal parts on the surface of three agar plates (detection limit: 10 cfu/g). The pour-plate method (using 1 or 10 mL of an appropriate dilution) was compared to the spread-plate method using the ISO-approved chromogenic medium Agar Listeria according to Ottaviani and Agosti (ALOA). Using the pour-plate method, the colony morphology and halo formation were similar to the spread-plate method from pure cultures and inoculated foods. Using the pourplate method in a 140 mm Petri dish, 10 mL of a 1:10 dilution of food allowed determination of numbers as low as 1 cfu/g. Applying this method, L. monocytogenes in naturally contaminated food samples were enumerated at numbers as low as 1-9 cfu/g.

https://doi.org/10.1515/ijafr-2017-0004

Monitoring of pilot-scale induction processes for dairy powders using inline and offline approaches

O'Sullivan J.J.; Schmidmeier C.; Drapala K.P.; O'Mahony J.A.; Kelly A.L.

Journal of Food Engineering, 2017

The induction of two dairy powders, skim milk powder (SMP; low-protein content), and milk protein isolate (MPI, high-protein content), was studied. The powder induction approaches investigated were (1) eductor alone, (2) eductor with a static mixer, and (3) eductor with high shear inline mixing. Measurement of pressure drop, from which viscosity was determined inline using the Hagen-Poiseuille equation, offline viscometry and particle size analyses were performed. High shear inline mixing provided the most efficient induction of powders. In addition, more rapid powder induction, as observed from particle size analysis, was achieved for SMP in comparison to MPI, owing to its better rehydration properties. Inline pressure drop data demonstrated that dissolution of MPI had two distinct phases: (i) powder introduction, and (ii) powder breakdown, irrespective of configuration and concentration employed. © 2016 Elsevier Ltd

https://doi.org/10.1016/j.jfoodeng.2016.10.023

Short communication: Multi-component interactions causing solidification during industrial-scale manufacture of pre-crystallized acid whey powders

Drapala K.P.; Murphy K.M.; Ho Q.T.; Crowley S.V.; Mulcahy S.; McCarthy N.A.; O'Mahony J.A.

Journal of Dairy Science, 2018

Acid whey (AW) is the liquid co-product arising from acid-induced precipitation of casein from skim milk. Further processing of AW is often challenging due to its high mineral content, which can promote aggregation of whey proteins, which contributes to high viscosity of the liquid concentrate during subsequent lactose crystallization and drying steps. This study focuses on mineral precipitation, protein aggregation, and lactose crystallization in liquid AW concentrates (~55% total solids), and on the microstructure of the final powders from 2 independent industrial-scale trials. These AW concentrates were observed to solidify either during processing or during storage (24 h) of pre-crystallized concentrate. The more rapid solidification in the former was associated with a greater extent of lactose crystallization and a higher ash-to-protein ratio in that concentrate. Confocal laser scanning microscopy analysis indicated the presence of a loose network of protein aggregates (≤10 μm) and lactose crystals (100–300 μm) distributed throughout the solidified AW concentrate. Mineral-based precipitate was also evident, using scanning electron microscopy, at the surface of AW powder particles, indicating the formation of insoluble calcium phosphate during processing. These results provide new information on the composition- and process-dependent physicochemical changes that are useful in designing and optimizing processes for AW.

https://doi.org/10.3168/jds.2018-14836

Effect of pH and heat treatment on viscosity and heat coagulation properties of milk protein concentrate

Ho Q.T.; Murphy K.M.; Drapala K.P.; O'Callaghan T.F.; Fenelon M.A.; O'Mahony J.A.; McCarthy N.A.

International Dairy Journal, 2018

The effect of pH, adjusted using either hydrochloric acid (HCl), citric acid or sodium hydroxide, on calcium ion (Ca2+) activity, and consequent changes in viscosity and heat coagulation time (HCT) of milk protein concentrate (MPC) was investigated. Reducing the pH of MPC dispersions resulted in a reduction in their viscosity, which subsequently increased during heat treatment. The maximum heat stability of MPC was observed at pH 6.7. Reducing the pH of MPC from 6.7 to 6.2 resulted in a significant ($P < 0.05$) increase in Ca2+ activity, and reduction in HCT. Such changes were more extensive using HCl compared with citric acid. Increasing the pH greater than 6.7 also led to a reduction in HCT but a decrease in Ca2+ activity. These results demonstrate the importance of pH adjustment, and choice of acidulant, on Ca2+ activity, viscosity, and heat coagulation properties of MPC concentrates during processing.

https://doi.org/10.1016/j.idairyj.2018.05.012

Research Programme: *Phase 1*

Influence of protein standardisation media and heat treatment on viscosity and related physicochemical properties of skim milk concentrate

Murphy K.M.; Ho Q.T.; Drapala K.P.; Keena G.M.; Fenelon M.A.; O'Mahony J.A.; McCarthy N.A.

International Dairy Journal, 2018

The effects of heat treatment and protein standardisation on the physical properties of skim milk concentrates were determined. Protein standardisation was carried out by the addition of lactose or milk permeate to skim milk. Unstandardised and standardised skim milk was subjected to heat treatment temperatures of 90 or 120 °C prior to evaporation whereafter the solids content was increased to 46% (w/w). Viscosity data showed non-standardised concentrates had the highest viscosity, followed by skim standardised with milk permeate followed by that standardised with lactose. Thermal treatment at 120 °C also resulted in a higher viscosity than that at 90 °C for all concentrates. Particle size data of evaporated skim milk showed a bimodal size distribution for skim milk standardised with liquid milk permeate, compared with monomodal distribution profiles for unstandardised skim milk and lactose standardised skim milk. Overall, this study showed that protein standardisation and standardisation media significantly affected concentrate properties. © 2018 Elsevier Ltd

https://doi.org/10.1016/j.idairyj.2018.01.010

Research Programme: *Phase 1*

The use of inline high-shear rotor-stator mixing for preparation of high-solids milk protein-stabilised oil-in-water emulsions with different protein:fat ratios

O'Sullivan J.J.; Drapala K.P.; Kelly A.L.; O'Mahony J.A.

Journal of Food Engineering, 2018

The emulsification of refined palm oil (RPO) in a continuous phase consisting of skim milk concentrate (SMC) and maltodextrin with a dextrose equivalent value of 17 (MD17) to produce fat-filled milk emulsions (FFMEs), was studied. A novel inline high-shear mixing (IHSM) method was used to produce emulsions, and three protein contents were investigated at a fixed RPO content of 12%: low (7.7%), medium (10.5%) and high (13%). Pressure drop measurement was used as an inline approach to determine viscosity using the Hagen-Poiseuille equation. In addition, offline viscometry, particle size and emulsion stability analyses were performed. Emulsion fat droplet size decreased significantly ($P < 0.05$) as a function of number of passes through the IHSM, due to an effective increase in residence time. Furthermore, inline pressure drop data demonstrated that the emulsification process displayed two distinct stages: (i) oil injection, and (ii) reduction in fat droplet size, irrespective of protein content.

https://doi.org/10.1016/j.jfoodeng.2017.10.015

Process analytical technology for cheese manufacture

Panikuttira B.; O'Shea N.; Tobin J.T.; Tiwari B.K.; O'Donnell C.P.

International Journal of Food Science and Technology, 2018

Recent research on the development and application of process analytical technology (PAT) for cheese manufacture is reviewed in this article. PAT is a framework for innovative process manufacturing and quality assurance, which has been widely investigated for dairy processing applications, where particular processing challenges arise due to the variations in the physiochemical properties of milk. Cheese manufacturers are increasingly considering the adoption of a PAT approach to facilitate manufacture of cheese with enhanced product quality, safety and process efficiency. However, to date adoption of PAT in the dairy industry has been limited due to challenges associated with development and validation of calibration models, instrument variability, sanitary design and compatibility with processing environments. New technical developments in PAT tools, advances in chemometric modelling, robust data management tools and improved understanding of critical product and process parameters will facilitate further adoption of a PAT approach in cheese manufacture.

https://doi.org/10.1111/ijfs.13806

Fly Ash Characterization from Cynara cardunculus L. Gasification

Serrano D.; Kwapinska M.; Sánchez-Delgado S.; Leahy J.J.

Energy and Fuels, 2018

This study analyzes the characteristics of fines produced during the air-blown gasification of Cynara cardunculus L. in a bubbling fluidized bed. These fines are collected by means of two hot cyclones and a hot filter. The gasification temperature is varied from 700 to 800 °C using olivine and magnesite as bed materials, with an equivalence ratio of 0.2. Relatively high carbon content is found in the entrained fines for all experiments. The lower heating value of the elutriated fines varies from 5.2 to 9.4 MJ/kgdb. Around 75% of the fines are captured in the first cyclone, 5% in the second cyclone, and the remaining 20% in the hot filter. The concentration of elements such as Se and Cl makes these fly ashes a hazardous material. Based on these properties the potential reuse of fly ashes is evaluated. © 2018 American Chemical Society.

https://doi.org/10.1021/acs.energyfuels.7b04050

The case for milk protein standardisation using membrane filtration for improving cheese consistency and quality

Soodam K.; Guinee T.P.

International Journal of Dairy Technology, 2018

Milk composition varies with season owing to stage of lactation and variation in diet and weather. Variation in the concentration of milk protein is conducive to inconsistency in cheese yield, composition and quality especially where standard operating procedures are not objectively standardised with reference to casein content. Milk protein standardisation (e.g. to 4.5%) by low-concentration factor ultrafiltration (LCFUF) or microfiltration (LCFMF) provides an effective means of obtaining more consistent cheese manufacture. Consequently, LCFUF is now widely practised. The benefits of LCFUF and LCFMF and the effect of key processing parameters on the quality of cheese from protein-standardised milk are reviewed. © 2018 Society of Dairy Technology

https://doi.org/10.1111/1471-0307.12502

Life cycle assessment of multi-product dairy processing using Irish butter and milk powders as an example

Yan M.; Holden N.M.

Journal of Cleaner Production, 2018

The Irish dairy industry faces a challenging market and a focus on the environmental impacts of products, both of which affect sustainable growth. The objectives of the study were to use life cycle assessment to analyse three products from four companies, to find the major contributors to energy use and greenhouse gas emissions, to understand the variation of environmental impacts and to identify the scope for improvement. Cumulative energy demand (CED) and carbon footprint (CF) of butter, skimmed milk powder (SMP), and fat filled powder (FFP) were calculated. The system boundary was from farm gate to processor gate to facilitate benchmarking. Data quality was generally sufficient, but data gaps were identified for steam sub-metering. Butter CED varied from 6.93 to 9.73 MJ/kg solids, butter CF from 0.41 to 0.62 kg CO2 eq/kg solids, SMP CED from 24.57 to 27.53 MJ/kg, SMP CF from 1.40 to 1.70 kg CO2 eq/kg solids, FFP CED was 26.14 MJ/kg solids and FFP CF was 1.65 CO2 eq/kg solids. Site specific data allowed explanation of variations by differentiating between practices and operational efficiency. Trade-off between renewable energy and ingredients revealed insights to the CF. Reactive power and wastewater treatment capacity demand further research. Valuable recommendations on how to better conduct LCA with industry were provided. This is the first such detailed analysis for the Irish dairy industry. It is important for the industry to move away from average data for impact management and to use site-specific data where possible. The allocation methodology, cascade structure of modelling, survey template, knowledge gaps identified, and the recommendations on conducting LCA with industry contributed to a general framework of LCA of dairy processing.

https://doi.org/10.1016/j.jclepro.2018.07.006

Effects of vibration parameters and pipe insertion depth on the motion of particles induced by vertical vibration

Zhang F.; Cronin K.; Lin Y.; Liu C.; Wang L.

Powder Technology, 2018

Granular particles can be induced to move against gravity upwards through a pipe or tube that is partially inserted under the powder free surface while subject to vertical vibration. This offers a new approach for transporting bulk material. In this paper, the effects of both vibration parameters and insertion depth of a pipe on particle motion are experimentally studied. A minimum vibration amplitude (A) and frequency (f) are necessary for particle motion to occur. There is a monotonic increase of the final rise height of the powder (heq) with increasing amplitude A. However, heq exhibits a non-monotonic dependence on frequency, f. There is an optimum frequency at which particles climb highest, and any further increase of frequency leads to a diminishment of this upwards motion. A phase diagram of particle movement is presented which shows that different zones of motion exist. This unique finding suggests that the mechanism of particle movement is caused by the creation and filling of voids under the tube. Particles cannot move upwards when the pipe insertion depth, hin is <1.5 mm irrespective of how strong the supplied vibration is. In general, increasing hin can improve climbing, but this effect falls with increasing levels of insertion depth until a saturation level is reached. PACS number: 45.70.MG - granular flow © 2017 Elsevier B.V.

https://doi.org/10.1016/j.powtec.2018.04.066

Dairy industry derived wastewater treatment sludge: Generation, type and characterization of nutrients and metals for agricultural reuse

Ashekuzzaman S.M.; Forrestal P.; Richards K.; Fenton O.

Journal of Cleaner Production, 2019

Globally, the processing of milk and dairy products leads to huge volumes of dairy processing wastewater treated sludge. Currently, there are knowledge gaps relating to the volumes generated and the nutrient and metal contents of these sludges. This lack of knowledge prevents the dairy processing industry from making informed pre and post waste generation decisions. Using Ireland as a case study volumes generated are estimated (2012–2017) and a two year seasonal database (2016–2018) across four sludge types (bio-chemically treated activated sludge; lime treated dissolved air flotation processing sludge; a combined treatment sludge and anaerobically digested sludge) utilising samples from nine dairy processing plants was created. Results show that dairy processing sludge increased by 39% in the period up to 126,718 tonnes (wet weight). Database results showed that nutrient contents did not vary seasonally but varied significantly across sludge type and processing plants. The median values (g kg−1 dry weight) for N:P:K for the four sludge types were N: 57.2, 19.5, 46 and 70.4, P: 36.8, 65.9, 20 and 14.6, and K: 7.2, 3.9, 2.9 and 6.1, respectively. Heavy metal concentrations across all samples were significantly lower than those regulated by the European Union for controlling metals accumulation in agricultural land due to sludge recycling. The characterization profile presented in this paper serves as a national and international reference database for future investigations that focus on the valorisation of dairy processing sludge.

https://doi.org/10.1016/j.jclepro.2019.05.025

Evaluation and validation of an inline Coriolis flowmeter to measure dynamic viscosity during laboratory and pilot-scale food processing

Bista A.; Hogan S.A.; O'Donnell C.P.; Tobin J.T.; O'Shea N.

Innovative Food Science and Emerging Technologies, 2019

Inline process analytical technology tools are increasingly employed in industry as they facilitate real time process parameter monitoring and optimization of product quality. Use of an inline viscometer in milk powder manufacture allows greater process control by monitoring the dynamic viscosity of the process concentrate pumped to the spray drier. In this study, an inline Promass I300 was used to measure the dynamic viscosity of both a Newtonian fluid (10–60% w/w sucrose solutions)and a non-Newtonian fluid (10–40% w/w skim milk concentrate)at laboratory scale at 25 °C. Validation of the instrument for measurement of a non-Newtonian fluid was completed at pilot-scale under similar operating conditions. Coefficient of determination (R2 = 0.99)was obtained between inline and offline viscosity measurements for both Newtonian and non-Newtonian fluids investigated. This study demonstrated the potential of an inline Coriolis flowmeter for rapid and accurate measurement of dynamic viscosity during processing of dairy streams. Industrial relevance: Control of milk concentrate viscosity during the manufacture of milk powder is critical to reduce energy consumption, reduce fouling and meet powder functional properties e.g. dispersability, flowability, particle size and powder hydration. The use of inline instruments for continuous monitoring of viscosity offers economic benefits to the producer as it can contribute to reduction in commonly encountered process issues such as fouling, blocking of nozzles and evaporator, which can result in process downtime and in extreme cases, product rework. Inline instruments can thus be employed to improve process control and reduce production waste during the manufacture of dairy powders.

https://doi.org/10.1016/j.ifset.2019.05.004

Transformation of organic contamination from wastewater into bioplastics (polyhydroxyalkanoate) by microorganisms

Fra-Vázquez A.; Palmeiro-Sánchez T.; Del Río A.; Mosquera-Corral A.

Wastewater Treatment Residues as Resources for Biorefinery Products and Biofuels, 2019

Biopolymers like polyhydroxyalkanoates (PHA) are potential candidates to substitute conventional plastics produced from petroleum. PHA are polymers with plastic properties and produced from mixed microbial cultures and renewable sources, like wastewater. Thus, they are biobased and biodegradable and named as bioplastics. In general, wastewater containing biodegradable organic matter is suitable to be used for PHA production. Wastewater from different industries (mainly from the agrofood sector) has been evaluated as substrate to produce PHA. Results indicate that between 6% and 65% of the organic matter contained in the wastewater is transformed into PHA. Different bacterial populations present in the activated sludge have the ability to accumulate these PHA in transient conditions, for example, of the presence-absence of organic matter or the so-called aerobic dynamic feeding (ADF). Although the use of wastewater and microbial mixed cultures to produce PHA is increasing in interest due to the substantial reduction of costs associated to the use of a waste and the required nonsterile conditions, several challenges have to be faced before the process scale up. The increase of volume productivity and the reduction of costs during the PHA extraction step are among them.

CareerFIT Publication

https://doi.org/10.1016/B978-0-12-816204-0.00018-7

Influence of calcium-binding salts on heat stability and fouling of whey protein isolate dispersions

Hebishy E.; Joubran Y.; Murphy E.; O'Mahony J.A.

International Dairy Journal, 2019

The effect of the calcium-binding salts (CBS), trisodium citrate (TSC), tripotassium citrate (TPC) and disodium hydrogen phosphate (DSHP) at concentrations of 1–45 mM on the heat stability and fouling of whey protein isolate (WPI) dispersions (3%, w/v, protein) was investigated. The WPI dispersions were assessed for heat stability in an oil bath at 95 °C for 30 min, viscosity changes during simulated high-temperature short-time (HTST) and fouling behaviour using a lab-scale fouling rig. Adding CBS at levels of 5–30 mM for TSC and TPC and 25–35 mM for DSHP improved thermal stability of WPI dispersions by decreasing the ionic calcium (Ca^{2+}) concentration; however, lower or higher concentrations destabilised the systems on heating. Adding CBS improved heat transfer during thermal processing, and resulted in lower viscosity and fouling. This study demonstrates that adding CBS is an effective means of increasing WPI protein stability during HTST thermal processing.

https://doi.org/10.1016/j.idairyj.2018.12.003

Modelling the changes in viscosity during thermal treatment of milk protein concentrate using kinetic data

Ho Q.T.; Murphy K.M.; Drapala K.P.; Fenelon M.A.; O'Mahony J.A.; Tobin J.T.; McCarthy N.A.

Journal of Food Engineering, 2019

This work aimed to model the effect of heat treatment on viscosity of milk protein concentrate (MPC) using kinetic data. MPC obtained after ultrafiltration was subjected to different time-temperature heat treatment combinations. Heat treatment at high temperature and short time (i.e., 100 or 120 °C×30 s) led to a significant increase in viscosity in MPC systems. Second-order reaction kinetic models proved a better fit than zero- or first-order models when fitted for viscosity response to heat treatment. A distinct deviation in the slope of the Arrhenius plot at 77.9 °C correlated to a significant increase in the rate of viscosity development at temperatures above this, confirming the transition of protein denaturation from the unfolding to the aggregation stage. This study demonstrated that heat-induced viscosity of MPC as a result of protein denaturation/aggregation can be successfully modelled in response to thermal treatment, providing useful new information in predicting the effect of thermal treatment on viscosity of MPC.

https://doi.org/10.1016/j.jfoodeng.2018.10.026

Heat and chemical treatments affect the viability, morphology, and physiology of Staphylococcus aureus and its subsequent antibody labeling for flow cytometric analysis

Kennedy, Deirdre, Cronin, Ultan P., Piterina, Anna, Wilkinson, Martin G.

Applied and Environmental Microbiology, 2019

The effects of heat and chemical treatments on Staphylococcus aureus viability and physiology and their subsequent effects on antibody binding ability and cell morphology were measured. Treatments included lethal and sublethal heat; exposure to organic acids, salt, and sodium hydroxide; and freeze-thawing. Strain-related differences in viability were noted depending on treatment and were reflected in changes in physiology as monitored by flow cytometry (FCM) using three different staining protocols: SYTO 9/propidium iodide (PI), DiOC2(3), or calcein acetoxymethyl ester (calcein-AM)/PI. Treatments that resulted in significant losses in viability as measured by plate counting were reflected better by the first two staining combinations, as intracellular calcein-AM uptake may have been impaired by certain treatments. FCM analysis using labeling by commercial anti-S. aureus antibodies indicated that differences in cell physiology as a result of treatments influenced immunofluorescence detection. The ratio of the mean fluorescence intensities of stained cells to those of unstained cells [MFI/MFI(us)] varied with treatment, five of these treatments, including freeze-thaw, citric acid, oxalic acid, NaCl, and NaOH treatments, resulted in significantly lower fluorescence values compared to controls.

IMPORTANCE FCM data indicated that cells conventionally considered to be dead and which would not give rise to CFU in a plate count assay, e.g., cells heated to 80°C, were labeled by antibody staining. This finding suggests that without the inclusion of a live/dead discriminating dye, these cells would be erroneously detected as viable within an FCM assay. Reductions in antibody staining due to physicochemical treatment were strain related, reflecting the complexity of the phenomenon under study and illustrating that substantial validation of any new antibody detection-based method, including physiological staining and cell sorting, should be undertaken. Researchers should be aware of physicochemical treatments causing false-negative results: in this study, freeze-thawing severely reduced antibody binding without affecting the viability of a substantial percentage of cells. Scanning electron microscopy carried out on treated cells revealed a range of morphological changes resulting from physicochemical treatments which may have hindered antibody binding.

CareerFIT Publication

https://doi.org/10.1128/AEM.01006-19

Occurrence and identification of spore-forming bacteria in skim-milk powders

Li F.; Hunt K.; Van Hoorde K.; Butler F.; Jordan K.; Tobin J.T.

International Dairy Journal, 2019

The different customer and regulatory specifications for mesophilic and thermophilic aerobic and anaerobic spore numbers in skim-milk powder, in addition to some specifications on specific spore-forming bacteria, such as Bacillus cereus, can be challenging for the industry to meet. Twenty-two samples of medium-heat skim-milk spray-dried powder from eight sources were analysed in triplicate with 16 bacterial and spore enumeration tests to understand the variety of spore-forming bacteria population. Using 16S rDNA sequencing, the species were identified for 269 isolates that were representative of the various tests. Of the isolates identified, 68% were Bacillus licheniformis, a facultative anaerobe that can survive and grow at mesophilic and thermophilic temperatures, making it difficult to eliminate in manufacturing environments. Using whole genome sequencing, 16 of 23 isolates identified as B. licheniformis by 16S sequencing were confirmed as B. licheniformis, four were identified as Bacillus paralicheniformis and three were identified as Bacillus sp. H15-1. © 2019 Elsevier Ltd

https://doi.org/10.1016/j.idairyj.2019.05.004

Analysing extraction uniformity from porous coffee beds using mathematical modelling and computational fluid dynamics approaches

Moroney K.M.; O'Connell K.; Meikle-Janney P.; O'Brien S.B.G.; Walker G.M.; Lee W.T.

PLoS ONE, 2019

Achieving a uniform extraction of soluble material from a porous matrix is a generic problem in various separation and filtration operations, with applications in the food processing, chemical and pharmaceutical industries. This paper describes models of fluid flow and transport of soluble material within a packed granular bed in the context of coffee extraction. Coffee extraction is described by diffusion of soluble material from particles of one or more representative sizes into fluid flowing through the packed bed. One-dimensional flow models are compared to computational fluid dynamics (CFD) models. A fine and a coarse coffee grind are considered. Model results are compared to experimental data for a packed cylindrical coffee bed and the influence of a change in geometry to a truncated cone is considered. Non-uniform flow in the truncated cone causes significant variation in the local extraction level. Coffee extraction levels during brewing are analysed using extraction maps and the degree of variation is represented on the industry standard coffee brewing control chart. A high variation in extraction yield can be expected to impart bitter flavours into the brew and thus is an important variable to quantify.

https://doi.org/10.1371/journal.pone.0219906

Pneumatic conveying of cohesive dairy powder: Experiments and CFD-DEM simulations

Olaleye A.K.; Shardt O.; Walker G.M.; Van den Akker H.E.A.

Powder Technology, 2019

We performed an experimental and numerical investigation of pneumatic conveying of cohesive dairy powder. The experiments with fat-filled milk powder (FFMP) fines with an average particle size of 94 μm were carried out in a 2-inch diameter stainless steel pipe consisting of two 2.5 m horizontal sections connected to a 0.65 m vertical section by two bends of 0.4 m radius each. In addition to measurements of pressure drop and powder deposition, an optical technique was used to measure the dynamics (probability densities) of local particle volume fractions as a function of operating conditions. Numerical simulations were performed with a commercial discrete element modelling (DEM) software, EDEM®, coupled with the computational fluid dynamics (CFD) software, FLUENT®. The simulation results in terms of pressure drops and particle volume fractions were compared with the experimental data. A very satisfactory agreement was found. At low gas velocities, cohesive dairy powders easily re-agglomerate after the second 90° bend and then deposit at the bottom of the horizontal pipe. At higher gas velocities, results show intermittent dispersion of particles and less particle deposition is observed even at higher loading ratio.

https://doi.org/10.1016/j.powtec.2019.09.046

Byproducts from Dairy Processing

Oliveira, D., Fox, P., O'Mahony, J.A.

Byproducts from Agriculture and Fisheries: Adding Value for Food, Feed, Pharma and Fuels, 2019

In the processing of milk, what might be considered a byproduct is arbitrary in some cases, e.g. in the manufacture of butter or butter oil, buttermilk and butter serum are clearly byproducts, whereas, in the separation of milk, either the cream or the skimmed milk could be the byproduct, depending on the objective of the process. This chapter considers cream and skimmed milk as byproducts. In dairy processing, the term permeate is used to describe the fraction of milk or its derived streams which can permeate through the selectively-permeable membranes used for fractionation, enrichment or purification of target nutrients using pressure-driven membrane filtration processing. Whey permeate, as a byproduct of whey processing, has been a dairy processing side stream since the introduction of UF technology in the 1960s for the removal and concentration of proteins from whey. The salts of milk are generally recovered as a component of dairy products.

CareerFIT Publication

https://doi.org/10.1002/9781119383956.ch4

Delactosed permeate as a dairy processing co-product with major potential value: a review

Oliveira, D., Puri, R., Fenelon, M.A., O'Mahony, J.A.

International Journal of Food Science and Technology, 2019

Delactosed permeate (DLP) is the co-product generated during the separation of pre-crystallised lactose from milk and whey permeates. DLP production has grown with the increased production of high protein content ingredients such as whey protein concentrates and isolates. Although DLP is nutritionally rich, with approximately 0.5–1.5, 68–70, 9–10 and 8–9 g/100 g dry matter of protein, total sugars, total mineral and organic acids, respectively, it is still currently underutilised, mostly for animal feed or energy production. There are a number of novel, promising and sustainable DLP-derived food and non-food applications which are the subject of current research. Therefore, there exists the opportunity to exploit this dairy co-product in the development of new value-added ingredients. In this comprehensive review, DLP production, processing challenges and potential applications are discussed, along with identification and assessment of selected strategies for the valorisation of DLP.

CareerFIT Publication

https://doi.org/10.1111/ijfs.14064

The application of process analytical technologies (PAT)to the dairy industry for real time product characterization - process viscometry

O'Shea N.; O'Callaghan T.F.; Tobin J.T.

Innovative Food Science and Emerging Technologies, 2019

The ideal PAT tool is an inline instrument that can monitor and measure process parameters simultaneously in real time while operating in a highly automated environment. Instruments must be of sanitary design, operate robustly within the full process cycle (production and cleaning). Inline determination of the rheological properties of moving fluids (i.e. dairy concentrates)is one of the process parameters where PAT tools can be add real value in terms of optimising process control. Measurement of process viscosity is crucial in the monitoring and control of a variety of concentration processes in the dairy industry. Continuous monitoring of the rheological behaviour of the fluid can allow for optimisation of the process e.g. pumping (avoid pump blockage and failure), evaporation (limit fouling and maximise water removal)and spray drying (avoidance of nozzle fouling). This review concentrates on the state of the art developments being made in the area of process viscometry. © 2019 Elsevier Ltd

https://doi.org/10.1016/j.ifset.2019.05.003

Atomisation technologies used in spray drying in the dairy industry: A review

O'Sullivan J.J.; Norwood E.-A.; O'Mahony J.A.; Kelly A.L.

Journal of Food Engineering, 2019

Atomisation is an integral element of the spray-drying process, whereby a bulk liquid feed is converted to discrete droplets, greatly increasing the surface area of the feed liquid and thereby increasing considerably the achievable rates of evaporation of water. These droplets, through evaporation of water in the main dryer chamber, become individual powder particles during the spray-drying process. This review provides a comprehensive examination of the most recent developments in atomisation technology for spray-drying, with a particular focus upon dairy applications (e.g., skim and whole milk powders, casein- and whey-based powders, and fat-filled milk powders). As well as a review of principles of different technologies for atomisation, such as rotary atomisers, pressure nozzle atomisers, pneumatic atomisers, ultrasonic atomisers and electrospray atomisers, the industrial applicability and challenges in use of each approach to atomisation are presented. Approaches for monitoring the atomisation process and other factors that influence atomisation, such as feed composition and key process parameters, are considered to provide a holistic analysis of the atomisation process. © 2018 Elsevier Ltd

https://doi.org/10.1016/j.jfoodeng.2018.08.027

High-Yield Synthesis of Poly(3-hydroxybutyrate- co-3-hydroxyvalerate) Copolymers in a Mixed Microbial Culture: Effect of Substrate Switching and F/M Ratio

Palmeiro-Sánchez T.; Val Del Rio A.; Fra-Vázquez A.; Luis Campos J.; Mosquera-Corral A.

Industrial and Engineering Chemistry Research, 2019

The accumulation capacity of a mixed microbial culture (MMC) is affected if the substrate used in the accumulation experiments differs from the one used in the enrichment. For this reason, the effect of substrate switching was studied to determine the versatility of an MMC enriched in a mixture of volatile fatty acids (VFAmix) to overcome this problem. The MMC was enriched using a VFAmix composed of 48.3:24.3:7.3:14.7 CmM acetic (HAc), propionic (HPr), butyric (HBu), and valeric (HVa) acids, respectively. The accumulation capacity was tested using single VFAs (HAc, HPr, HBu, and HVa), as well as the VFAmix used in the enrichment. The accumulation capacities were 52.8 ± 4.7, 48.8 ± 4.3, 45.2 ± 3.0, 48.4 ± 1.0, and 54.5 ± 8.0 wt% for HAc, HPr, HBu, HVa, and VFAmix, respectively, with polymer compositions of 50.6 ± 15.1, 0.4 ± 0.1, 63.2 ± 1.5, 0.3 ± 0.0, and 2.0 ± 0.7 g 3-HB/g 3-HV, following the same order. The average yields were 0.84 ± 0.08, 0.76 ± 0.09, 0.74 ± 0.02, 0.70 ± 0.01, and 0.68 ± 0.09 CmolPHA/CmolVFA for HVa, VFAmix, HAc, HBu, and HPr, respectively. The feed-to-microorganism (F/M) ratio showed that values of 1-7 CmolVFA/(CmolX) in the accumulation experiments led to the optimal yields. Based on the results obtained, it seems feasible to enrich an MMC able to produce tailor-made biopolymers from different VFAs at high yields. © 2019 American Chemical Society.

CareerFIT Publication

https://doi.org/10.1021/acs.iecr.9b03514

Evaluation of a fluorescence and infrared backscatter sensor to monitor acid induced coagulation of skim milk

Panikuttira B.; Payne F.A.; O'Shea N.; Tobin J.T.; O'Donnell C.P.

Innovative Food Science and Emerging Technologies, 2019

A prototype sensor that employs both ultraviolet excited fluorescence and infrared light backscatter was evaluated as an in-line process analytical technology (PAT)tool to monitor acid induced coagulation kinetics of skim milk. Coagulation experiments were carried out at 32 ° C using three concentrations of glucono-delta-lactone (GDL). Measurement of storage modulus (G′)of acidified skim milk gel was used as a reference rheological method to monitor the coagulation kinetics. Prediction models were developed to predict the times required for acidified skim milk coagulum to reach selected G′ values (0.5 Pa, 1 Pa, 5 Pa, 10 Pa and 15 Pa)using time parameters extracted from the ultraviolet excited fluorescence and infrared light backscatter profiles. A strong correlation was observed between the predicted times developed using time parameters extracted from the prototype sensor profiles and the measured G′ times extracted from the rheometer (R2 = 0.97, standard error of prediction = 2.8 min). This study concluded that the prototype fluorescence and infrared backscatter sensor investigated combined with the developed rheological prediction model can be used as a potential PAT tool for in-line monitoring of coagulation kinetics in the manufacture of acid induced milk gels. Industrial relevance: The prototype fluorescence and infrared backscatter sensor investigated in this study combined with the developed rheological prediction model can be employed to monitor and control coagulation kinetics in a wide range of dairy processing applications including fresh cheese varieties and yoghurt manufacture. © 2019 Elsevier Ltd

https://doi.org/10.1016/j.ifset.2019.04.011

Elucidation of factors responsible for formation of white flecks in reconstituted fat filled milk powders

Schmidmeier C.; O'Gorman C.; Drapala K.P.; Waldron D.S.; O'Mahony J.A.

Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2019

Fat filled milk powders (FFMP) are formulated by blending skim milk and vegetable oil, to which lactose, permeate, sugar, maltodextrin, vitamins and minerals may also be added. The liquid mix is usually homogenised and spray dried, with agglomeration and lecithination, to produce powders for a range of end-user applications including drinking milk, yoghurt base and coffee whitening. Thus, it is important to avoid common powder defects such as inconsistent whitening, feathering or white flecking on reconstitution. The phenomenon of white flecking, and in particular, the underlying causes of fleck formation, are poorly understood. To better understand white fleck formation, six size fraction samples from two different FFMPs, a good (low level flecking) and a poor powder (high level flecking), were profiled. Most extensive flecking was observed in the coarse fraction of the poor powder, which also had an 8-fold higher free fat content than all other fractions and displayed poor emulsion stability (D3,2 = 15 ± 3.9 μm compared to 0.45-0.75 μm for all other fractions). Treatment of the reconstituted emulsions with an anionic surfactant or a reducing agent suggested that integrity of white flecks was based mainly on electrostatic interactions between proteins, with little contribution from covalent bonds. Although the extent of whey protein denaturation ranged between 22.6–47.5%, whey protein insolubility appeared to play a sub-ordinate role in white fleck formation. These results suggest that presence of flecks in FFMP was mainly associated with poor thermal stability of the emulsions.

https://doi.org/10.1016/j.colsurfa.2019.03.034

The effect of agglomerate integrity and blending formulation on the mechanical properties of whey protein concentrate powder tablets

Schmidmeier C.; Wen Y.; Drapala K.P.; Dennehy T.; McGuirke A.; Cronin K.; O'Mahony J.A.

Journal of Food Engineering, 2019

In this work, the strength of tablets made from mixtures of whey protein concentrate (WPC) powder and different types of sugar was investigated. The agglomerated WPC powder was pneumatically conveyed (lean phase) at three different air speeds of 10, 20 or 30 m/s to simulate the effects of industrial powder transport, resulting in agglomerates with reduced integrity. Conveyed and control WPC powder, and sugar of three different particle size distributions (i.e., granulated, GS; caster, CS and icing sugar, IS) were analysed for microstructure, particle size, moisture, and flowability. Tensile strength of tablets from WPC powder alone or blended with 0.5–10% sugar was tested. Conveying of WPC powder led to a significant increase in tablet strength, (i.e., from failure strength of 1.67 N/mm 2 for control tablets to 2.33, 2.11 and 2.11 N/mm 2 after conveying at 10, 20 or 30 m/s, respectively), suggesting that the generation of smaller powder particles led to increased mechanical strength of tablets. The addition of sugar also resulted in a significant increase in tablet strength (e.g., failure strength of 2.34, 2.12 and 2.47 N/mm 2 at 1.5% addition level of GS, CS and IS, respectively) and strongest tablets were obtained at 1.5–3% sugar addition and by blending with icing sugar. This study demonstrated, for the first time, that conveying and dry blending of whey protein and sugar powders significantly influenced the rheological properties of resultant tablets.

https://doi.org/10.1016/j.jfoodeng.2018.11.029

Water use efficiency of Irish dairy processing

Yan M.-J.; Holden N.M.

Journal of Dairy Science, 2019

Dairy processing uses a significant amount of water for processing and cleaning. Withdrawing and distributing water and treating wastewater represent significant costs to the Irish dairy processing industry. Stringent discharge limits also add pressure for water use efficiency, particularly during peak production months. Improving water use efficiency is therefore critical for Irish dairy processing. We conducted a detailed analysis of water use efficiency in 4 Irish dairy processing plants. Using farm gate to processor gate (gate-to-gate) life cycle assessment, we assessed on-site water data quality and investigated gate-to-gate volumetric water use and eutrophication potential (EP) for 3 common dairy products. We also benchmarked the on-site water use and water balance, characterized wastewater nutrient load, analyzed the influencers of on-site water use, and identified scope for increased water use efficiency. We found that condensate from evaporation represented a significant input at the site level (0.51 to 1.14 L/L of fresh water purchased or extracted from nature). In terms of gate-to-gate volumetric water use, butter used 1,326 to 1,843 m3/t of solids, with electricity being the largest contributor, whereas milk powders used 3,006 to 3,754 m3/t of solids, with electricity and ingredients being the largest contributors. Eutrophication of butter was found to be 0.51 to 0.77 kg of PO4 equivalents (eq)/t of solids, with transportation and nutrient emissions from wastewater treatment being the largest contributors. Eutrophication of milk powder was found to be 0.96 to 3.35 kg of PO4 eq/t of solids, and contributions varied depending on powder specifications. Milk intake water use and various leakages were found to be hotspots that could be managed to reduce water use on site. Comprehensive metering is urgently needed to improve water use efficiency in light of the ongoing expansion of dairy production and hence processing in Ireland. Significant opportunities exist to optimize operator behavior, water reuse, and off-site transportation and energy. This study represents the first attempt to define water efficiency opportunities both at the site level and along the supply chain. Processors need to be aware of off-site contributors that significantly affect both volumetric water use and environmental impacts of processed dairy products. © 2019 American Dairy Science Association

https://doi.org/10.3168/jds.2019-16518

Gaps in the assortment of rapid assays for microorganisms of interest to the dairy industry

John O'Grady a, Ultan Cronin b, Joseph Tierney c, Anna V. Piterina a, Elaine O'Meara b, Martin G. Wilkinson

Advances in Applied Microbiology, 2020

This review presents the results of a study into the offering of rapid microbial detection assays to the Irish dairy industry. At the outset, a consultation process was undertaken whereby key stakeholders were asked to compile a list of the key microorganisms of interest to the sector. The resultant list comprises 19 organisms/groups of organisms divided into five categories: single pathogenic species (Cronobacter sakazakii, Escherichia coli and Listeria monocytogenes); genera containing pathogenic species (Bacillus, Clostridium, Listeria, Salmonella; Staphylococcus); broad taxonomic groupings (Coliforms, Enterobacteriaceae, fecal Streptococci, sulfite reducing bacteria/sulfite reducing Clostridia [SRBs/SRCs], yeasts and molds); organisms displaying certain growth preferences or resistance as regards temperature (endospores, psychrotrophs, thermodurics, thermophiles); indicators of quality (total plate count, Pseudomonas spp.). A survey of the rapid assays commercially available for the 19 organisms/groups of organisms was conducted. A wide disparity between the number of rapid tests available was found. Four categories were used to summarize the availability of rapid assays per organism/group of organisms: high coverage (> 15 assays available); medium coverage (5–15 assays available); low coverage (< 5 assays available); no coverage (0 assays available). Generally, species or genera containing pathogens, whose presence is regulated-for, tend to have a good selection of commercially available rapid assays for their detection, whereas groups composed of heterogenous or even undefined genera of mainly spoilage organisms tend to be "low coverage" or "no coverage." Organisms/groups of organisms with "low coverage" by rapid assays include: Clostridium spp.; fecal Streptococci; and Pseudomonas spp. Those with "no coverage" by rapid assays include: endospores; psychrotrophs; SRB/SRCs; thermodurics; and thermophiles. An important question is: why have manufacturers of rapid microbiological assays failed to respond to the necessity for rapid methods for these organisms/groups of organisms? The review offers explanations, ranging from the technical difficulty involved in detecting as broad a group as the thermodurics, which covers the spores of multiple sporeforming genera as well at least six genera of mesophilic nonsporeformers, to the taxonomically controversial issue as to what constitutes a fecal Streptococcus or SRBs/SRCs. We review two problematic areas for assay developers: validation/certification and the nature of dairy food matrices. Development and implementation of rapid alternative test methods for the dairy industry is influenced by regulations relating to both the microbiological quality standards and the criteria alternative methods must meet to qualify as acceptable test methods. However, the gap between the certification of developer's test systems as valid alternative methods in only a handful of representative matrices, and the requirement of dairy industries to verify the performance of alternative test systems in an extensive and diverse range of dairy matrices needs to be bridged before alternative methods can be widely accepted and adopted in the dairy industry. This study concludes that many important dairy matrices have effectively been ignored by assay developers.

https://doi.org/10.1016/bs.aambs.2020.07.001

Protein A-Mediated Binding of Staphylococcus spp. to Antibodies in Flow Cytometric Assays and Reduction of This Binding by Using Fc Receptor Blocking Reagent

Ultan P. Cronin, Laura Girardeaux, Elaine O'Meara, Martin G. Wilkinson

Applied and Environmental Microbiology, 2020

Staphylococcus aureus and other coagulase-positive Staphylococcus spp. bind the Fc region of IgG antibodies through expression of protein A (SpA). These species have consequently been a source of false-positive signals in antibody-based assays designed to detect other target bacteria. Here, flow cytometry was used to study the influence of a number of factors on the SpA-mediated binding of single cells to an anti-human IgG antibody, including strain, heat killing, overnight storage, growth phase, cell physiology, surface adhesion, and growth in model food systems. Through the costaining of antibody-stained cells with the permeability dye propidium iodide and calcein violet AM, the cell physiological status was related to SpA-mediated antibody binding. Generally, permeabilized cells lacking esterase activity did not strongly bind antibody. The binding of a number of commercially available polyclonal IgG antibodies to non-Staphylococcus spp. was also characterized. Not all SpA-expressing species showed strong binding of mouse IgG, and one species not known to express SpA showed strong binding. Most SpA-expressing strains bound rabbit IgG antibodies to some extent, whereas only one strain bound goat IgG. To reduce or eliminate SpA-mediated IgG binding, the following products were evaluated as blocking reagents and applied prior to staining with primary or secondary antibody: normal rabbit serum, mouse IgG isotype control, goat IgG, and a commercial FcR blocking reagent. Only the FcR blocking reagent consistently reduced SpA-mediated binding of Staphylococcus spp. to antibodies against other species and could be recommended as a blocking reagent in immunoassays designed to detect non-Staphylococcus species.

CareerFIT Publication

https://doi.org/10.1128/aem.01435-20

Bioconversion of organic pollutants in fish-canning wastewater into volatile fatty acids and polyhydroxyalkanoate

Palmeiro-Sánchez T.; Campos J.L.; Mosquera-Corral A.

International Journal of Environmental Research and Public Health, 2021

The wastewater from the cookers of a tuna-canning plant was used as feedstock for the process. It was acidified in a continuous stirred tank reactor (CSTR) of 1.5 L to produce a mixture of volatile fatty acids (VFAs). The effluent contained 28.3 ± 8.7 g CODS/L and 25.0 ± 4.6 g CODVFA/L, 4.4 ± 1.6 g NH4+/L, and 10.9 ± 4.0 g Na+/L, which corresponds to about 28 g NaCl/L approximately. This was used to feed a PHA production system. The enriched MMC presented a capacity to accumulate PHAs from the fermented tuna wastewater. The maximum PHA content of the biomass in the fed-batch (8.35 wt% PHA) seemed very low, possibly due to the variable salinity (from 2.2 up to 12.3 g NaCl/L) and the presence of ammonium (which promoted the biomass growth). The batch assay showed a PHA accumulation of 5.70 wt% PHA, but this is a much better result if the productivity of the reactor is taken into account. The fed-batch reactor had a productivity of 10.3 mg PHA/(L h), while the batch value was about five times higher (55.4 mg PHA/(L h)). At the sight of the results, it can be seen that the acidification of fish-canning wastewater is possible even at high saline concentrations (27.7 g NaCl/L). On the other hand, the enrichment and accumulation results show us promising news and which direction has to be followed: PHAs can be obtained from challenging substrates, and the feeding mode during the accumulation stage has an important role to play when it comes to inhibition.

CareerFIT Publication

https://doi.org/10.3390/ijerph181910176

Psychrophilic and mesophilic anaerobic treatment of synthetic dairy wastewater with long chain fatty acids: Process performances and microbial community dynamics

Liu, YC; Ramiro-Garcia, J; Paulo, LM; Braguglia, CM; Gagliano, MC; O'Flaherty, V

BIORESOURCE TECHNOLOGY, 2023

Facilitating the anaerobic degradation of long chain fatty acids (LCFA) is the key to unlock the energy potential of lipids-rich wastewater. In this study, the feasibility of psychrophilic anaerobic treatment of LCFA-containing dairy wastewater was assessed and compared to mesophilic anaerobic treatment. The results showed that psychrophilic treatment at 15 ℃ was feasible for LCFA-containing dairy wastewater, with high removal rates of soluble COD (>90%) and LCFA (~100%). However, efficient long-term treatment required prior acclimation of the biomass to psychrophilic temperatures. The microbial community analysis revealed that putative syntrophic fatty acid bacteria and Methanocorpusculum played a crucial role in LCFA degradation during both mesophilic and psychrophilic treatments. Additionally, a fungal-bacterial biofilm was found to be important during the psychrophilic treatment. Overall, these findings demonstrate the potential of psychrophilic anaerobic treatment for industrial wastewaters and highlight the importance of understanding the microbial communities involved in the process.

http://dx.doi.org/10.1016/j.biortech.2023.129124

A review of MIR, NIR, Fluorescence and Raman spectroscopy combined with chemometric modelling to predict the functional properties of raw bovine milk

Ní Fhuaráin, A.; O'Donnell, C.P.; Luo, J.; Gowen, A.A.

Professor Aoife Gowen,

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ACS Food Science and Technology, 2024

Spectroscopic methods, such as Mid-Infrared (MIR), Near-Infrared (NIR), fluorescence and Raman spectroscopy are rapid, inexpensive and nondestructive. Traditionally, mainly MIR and NIR spectroscopy have been employed to predict the compositional properties of milk. However, measurement of the key functional properties of milk is of high industry relevance. In this review, studies on the use of spectroscopic techniques for predicting milk functional properties are compared and reported models are outlined. The challenges of employing spectroscopy in functionality applications are discussed. For pH and curd yield, some of the MIR models display a robust prediction performance. With further model validation, calibrations for these properties could potentially be added to existing MIR instruments in the industry. Despite fluorescence and NIR spectroscopy being used for many dairy applications, their use for milk functionality is limited currently. As Raman spectroscopy is sensitive to the components of raw milk, it has potential for predicting milk functional properties.

https://doi.org/10.1021/acsfoodscitech.4c00130

Monitoring Viscosity and Total Solids Content of Milk Protein Concentrate Using an Inline Acoustic Flowmeter at Laboratory Scale

Bista, A; Tobin, JT; O'Donnell, CP; O'Shea, N

Foods, 2020

Control of milk concentrate viscosity and total solids (TS) content prior to spray drying can improve dairy ingredient manufacture. However, the availability of hygienic and appropriately pressure rated process viscometers for inline monitoring of viscosity is limited. An acoustic flowmeter (FLOWave) is an inline process analytical technology (PAT) tool that measures changes in acoustic signals in response to changes in liquid properties (i.e., acoustic transmission (AT), acoustic impedance (AI), temperature and volume flowrate). In this study, an acoustic flowmeter is evaluated as an inline PAT tool for monitoring viscosity of milk protein concentrate (MPC85), protein and TS content of (MPC85), and standardised MPC (sMPC). Laboratory scale experiments were carried out at 45 °C for five different concentrations (4–21%) of MPC85 and sMPC. Results showed that AT decreased with an increase in MPC85 viscosity (e.g., AT was 98.79 ± 0.04% and 86.65 ± 0.17% for 4% and 21% TS content, respectively). Non-linear regression was carried out to develop a relationship between AT and offline viscosity (R2 (coefficient of determination) value = 0.97 and standard error of prediction = 1.86 mPa·s). AI was observed to increase at higher protein and TS content which was dependent on protein to total solid ratio (P_TSR). Multiple linear regression was carried out to develop the relationship between AI, protein content, TS content and P_TSR. Results demonstrated that AI could be used to monitor the protein and TS content of milk protein concentrate (R2 > 0.96). Overall this study demonstrated the potential of an inline acoustic flowmeter for monitoring process viscosity, protein and TS during dairy concentrate processing.

http://dx.doi.org/10.3390/foods9091310

Polyhydroxyphenylvalerate/polycaprolactone nanofibers improve the life-span and mechanoresponse of human IPSC-derived cortical neuronal cells

Cerrone F.; Pozner T.; Siddiqui A.; Ceppi P.; Winner B.; Rajendiran M.; Babu R.; Ibrahim H.S.; Rodriguez B.J.; Winkler J.; Murphy K.J.; O'Connor K.E.

Materials Science and Engineering C, 2020

The physico-chemical characteristics of the extracellular matrix (ECM) cause mechanical cues that could elicit responses in the survival rate of cortical neuronal cells. Efficient neurite outgrowth in vitro, is critical for successful cultivation of cortical neuronal cells and the potential for attempts at regeneration of the central nervous system (CNS) in vivo. Relatively soft and hydrophilic, microbially synthesized aromatic polyester, polyhydroxyphenylvalerate (PHPV) was blended 50:50 with the stiff and hydrophobic polycaprolactone (PCL) and electrospun in microfibers for use in a 3D (CellCrown™) configuration and in a 2D coverslip coated configuration. This blend allows a 2.3-fold increase in the life-span of human induced pluripotent stem derived cortical neuronal cells (hiPS) compared to pure PCL fibers. HiPS-derived cortical neuronal cells grown on PHPV/PCL fibers show a 3.8-fold higher cumulative neurite elaboration compared to neurites grown on PCL fibers only. 96% of cortical neuronal cells die after 8 days of growth when plated on PCL fibers alone while >83% and 55% are alive on PHPV/PCL fibers on day 8 and day 17, respectively. An increased migration rate of cortical neuronal cells is also promoted by the blend compared to the PCL fibers alone. The critical survival rate improvement of hiPS derived cortical neuronal cells on PHPV/PCL blend holds promise in using these biocompatible nanofibers as implantable materials for regenerative purposes of an active cortical neuronal population after full maturation in vitro. © 2020 Elsevier B.V.

https://doi.org/10.1016/j.msec.2020.110832

Research Programme: *Phase 2, RFA1*

Protein a-mediated binding of staphylococcus spp. To antibodies in flow cytometric assays and reduction of this binding by using Fc receptor blocking reagent

Cronin U.P.; Girardeaux L.; O'Meara E.; Wilkinson M.G.

Applied and Environmental Microbiology, 2020

Staphylococcus aureus and other coagulase-positive Staphylococcus spp. bind the Fc region of IgG antibodies through expression of protein A (SpA). These species have consequently been a source of false-positive signals in antibody-based assays designed to detect other target bacteria. Here, flow cytometry was used to study the influence of a number of factors on the SpA-mediated binding of single cells to an anti-human IgG antibody, including strain, heat killing, overnight storage, growth phase, cell physiology, surface adhesion, and growth in model food systems. Through the costaining of antibody-stained cells with the permeability dye propidium iodide and calcein violet AM, the cell physiological status was related to SpA-mediated antibody binding. Generally, permeabilized cells lacking esterase activity did not strongly bind antibody. The binding of a number of commercially available polyclonal IgG antibodies to non-Staphylococcus spp. was also characterized. Not all SpA-expressing species showed strong binding of mouse IgG, and one species not known to express SpA showed strong binding. Most SpA-expressing strains bound rabbit IgG antibodies to some extent, whereas only one strain bound goat IgG. To reduce or eliminate SpA-mediated IgG binding, the following products were evaluated as blocking reagents and applied prior to staining with primary or secondary antibody: normal rabbit serum, mouse IgG isotype control, goat IgG, and a commercial FcR blocking reagent. Only the FcR blocking reagent consistently reduced SpA-mediated binding of Staphylococcus spp. to antibodies against other species and could be recommended as a blocking reagent in immunoassays designed to detect non-Staphylococcus species. IMPORTANCE This study characterizes a widespread but little-studied problem associated with the antibody-based detection of microbes-the Staphylococcus protein A (SpA)-mediated binding of IgG antibodies-and offers a solution: the use of commercial FcR blocking reagent. A common source of false-positive signals in the detection of microbes in clinical, food, or environmental samples can be eliminated by applying this study's findings. Using flow cytometry, the authors demonstrate the extent of heterogeneity in a culture's SpA-mediated binding of antibodies and that the degree of SpA-mediated antibody binding is strain, growth phase, and food matrix dependent and influenced by simulated food processing treatments and cell adherence. In addition, our studies of SpA-mediated binding of Staphylococcus spp. to antibodies against other bacterial species produced a very nuanced picture, leading us to recommend testing against multiple strains of S. aureus and S. hyicus of all antibodies to be incorporated into any immunoassay designed to detect a non-Staphylococcus spp. © 2020 Cronin et al.

CareerFIT Publication

https://doi.org/10.1128/AEM.01435-20

Physicochemical and gelling properties of whey protein hydrolysates generated at 5 and 50 °C using Alcalase® and Neutrase®, effect of total solids and incubation time

Dermiki M.; FitzGerald R.J.

International Dairy Journal, 2020

Gelation temperature (Tg), apparent viscosity (ηapp), turbidity and chromatography profiles of whey protein concentrate (WPC) and corresponding hydrolysates (WPHs) generated with Alcalase® and Neutrase® at different temperatures and total solids (TS) were compared. WPC incubated with Alcalase at 50 °C exhibited the highest rate and degree of hydrolysis (DH). After 4 h, the 5 °C Alcalase WPH (10% TS) had a DH and molecular mass distribution similar to those generated at 5 and 50 °C with Neutrase; however, the chromatography profiles differed. Tg was lower for WPHs than for WPC and depended on both the enzyme and TS. Moreover, the Tgs were lower for the Alcalase hydrolysates than for those generated with Neutrase. The ηapp and turbidity properties of the hydrolysates depended on the enzyme used, solution TS and incubation temperature. Hydrolysates had lower ηapp than WPC. The 50 °C Neutrase hydrolysates displayed lower turbidity than the corresponding Alcalase hydrolysates. © 2020 Elsevier Ltd

http://dx.doi.org/10.1016/j.idairyj.2020.104792

Incorporating sustainable criteria in a dynamic multi-objective recommendation planning tool for a continuous manufacturing process: A dairy case study

Eccher C.; Geraghty J.

Journal of Manufacturing Systems, 2020

The activity of scheduling the production plan with the aim of achieving an optimal criterion has been explored in literature for several manufacturing sectors, in particular when it comes to solving scheduling NP-complete problems. In Dairy Manufacturing, determining an optimum criterion for the scheduling process has numerous internal and external challenges due to the complexity of this environment. The initial stages in the Dairy process are characterised by a continuous manufacturing environment and specific operational issues are observable: interruptions for the accomplishment of Cleaning-In-Place (CIP); a short raw material lifespan which demands a fast processing rate; and the stochastic raw material supply variation. By highlighting these three aspects, a critical trade-off emerges: CIP cycle-times heavily reduce the processing capacity, whereas the raw material processed requires an increase in available capacity due to the impact of seasonality, perishability and stochastic deliveries. Therefore, the scheduling plan must be dynamically readapted based on the current inventory, volume and frequency supplied, CIP cycle-times, maximum equipment running hours and downstream capacities. The aim of this research is to develop an integrated approach for generating equipment schedules under supply uncertainty typically observed in the dairy sector where criteria of sustainability are effortlessly incorporated for an improved decision-making process. An efficient Multi-objective Algorithm (MOA) combining conflicting key performance metrics such as minimising Work-In-Process (WIP), maximising Service Level Agreement (SLA), Utilisation and Energy consumption is proposed. The novelty consists of the ability to dynamically select trade-off criteria and visualise the optimum production plan according to the conditions defined by the decision-maker. The appropriate schedules are presented in a Pareto Frontier graph highlighting the entire non-dominance region according to the volume and frequency supplied. Even though sustainability metrics are usually ignored during production plan definitions, namely when a weak correlation between both environmental and profitable criteria is identified, the results demonstrate improved performance when both sustainable approaches are well explored.

https://doi.org/10.1016/j.jmsy.2020.02.008

Application of in silico approaches for the generation of milk protein-derived bioactive peptides

FitzGerald R.J.; Cermeño M.; Khalesi M.; Kleekayai T.; Amigo-Benavent M.

Journal of Functional Foods, 2020

Milk protein derived peptides have numerous well-documented bioactive properties. The conventional approach for the generation, identification and validation of bioactive peptides (BAPs) has involved (i) protein hydrolysis, (ii) bioactivity screening and (iii) validation in vivo. The low potency (in comparison to conventional drugs), susceptibility to breakdown during gastrointestinal transit and low intestinal permeability are key challenges in the development of highly bioactive food protein hydrolysates/peptides. However, the generation of potent and effective health enhancing hydrolysates/peptides can benefit from a range of in silico techniques including the application of structure bioactivity relationship modelling (e.g., quantitative structure activity relationship (QSAR) modelling), molecular docking and design of experiments (DOE) approaches to optimise BAP production and identification. Some examples of how these approaches have been employed in BAP discovery and generation will be outlined.

http://dx.doi.org/10.1016/j.jff.2019.103636

Influence of mechanical integrity during pneumatic conveying on the bulk handling and rehydration properties of agglomerated dairy powders

Hazlett R.; Schmidmeier C.; O'Mahony J.A.

Journal of Food Engineering, 2020

Agglomerated powders are susceptible to breakdown on handling, most notably, during powder conveying. In this study, three agglomerated dairy powders (whey protein concentrate powder, WPC; fat-filled milk powder, FFMP and infant formula powder, IF) were conveyed through a custom-fabricated dispersion rig to understand the effects of agglomerate breakdown on dairy powder handling and application. All samples displayed significant breakdown on dispersion, evidenced by reducing particle size and increasing bulk density. The resulting flowability of these powders was impaired (flow index: WPC: 9.3 to 5.1, FFMP: 5.7 to 4.9 and IF: 16 to 10) via increased particle-particle interactions. The initial stages of rehydration were impeded by agglomerate breakage (42.9–47.0% wettability reduction and 7.22–16.4% dispersibility reduction), while powder solubility remained relatively unchanged. This study provides insights into the alterations of agglomerated dairy powder properties on agglomerate breakdown, while identifying the effects these alterations have on the functional properties of these powders. © 2020 Elsevier Ltd

https://doi.org/10.1016/j.jfoodeng.2020.110103

In vitro characterisation of the antioxidative properties of whey protein hydrolysates generated under pH- And non pH-controlled conditions

Kleekayai T.; Le Gouic A.V.; Deracinois B.; Cudennec B.; FitzGerald R.J.

Foods, 2020

Bovine whey protein concentrate (WPC) was hydrolysed under pH-stat (ST) and non pH-controlled (free-fall, FF) conditions using Debitrase (DBT) and FlavorPro Whey (FPW). The resultant whey protein hydrolysates (WPHs) were assessed for the impact of hydrolysis conditions on the physicochemical and the in vitro antioxidant and intracellular reactive oxygen species (ROS) generation in oxidatively stressed HepG2 cells. Enzyme and hydrolysis condition dependent differences in the physicochemical properties of the hydrolysates were observed, however, the extent of hydrolysis was similar under ST and FF conditions. Significantly higher ($p < 0.05$) in vitro and cellular antioxidant activities were observed for the DBT compared to the FPW–WPHs. The WPHs generated under ST conditions displayed significantly higher ($p < 0.05$) oxygen radical absorbance capacity (ORAC) and Trolox equivalent antioxidant capacity (TEAC) values compared to the FF-WPHs. The impact of hydrolysis conditions was more pronounced in the in vitro compared to the cellular antioxidant assay. WPH peptide profiles (LC-MS/MS) were also enzyme and hydrolysis conditions dependent as illustrated in the case of β-lactoglobulin. Therefore, variation in the profiles of the peptides released may explain the observed differences in the antioxidant activity. Targeted generation of antioxidant hydrolysates needs to consider the hydrolysis conditions and the antioxidant assessment method employed.

https://doi.org/10.3390/foods9050582

The effects of sequential heat treatment on microbial reduction and spore inactivation during milk processing

Li F.; Hunt K.; Buggy A.K.; Murphy K.M.; Ho Q.T.; O'Callaghan T.F.; Butler F.; Jordan K.; Tobin J.T.

International Dairy Journal, 2020

Sequential heating processes are commonly applied to milk by the dairy industry as part of their microbiological control strategy. Often pasteurisation at 72 °C is followed by a sequential high heat treatment step of up to 125 °C; however, such severe heat treatment can lead to reduced protein quality. Nine temperature combinations (80–90 °C) were evaluated to assess microbial reduction and whey protein nitrogen index values during pilot scale milk processing. A total of 110 bacterial isolates were identified to species level by 16S rDNA sequencing, with Bacillus licheniformis identified as the dominant species. While the experimental treatments did not achieve microbial reductions comparable with the control heating process, the results of this study provide a benchmark for milk processors relative to the effects of sequential heat treatments on milk and their impact on the survival of both thermally resistant microbial populations and thermally labile milk components during processing.

https://doi.org/10.1016/j.idairyj.2020.104648

Milk fat: opportunities, challenges and innovation

Mohan M.S.; O'Callaghan T.F.; Kelly P.; Hogan S.A.

Critical Reviews in Food Science and Nutrition, 2020

Milk fat is a high-value milk component that is processed mainly as butter, cheese, cream and whole milk powder. It is projected that approximately 35 million tonnes of milk fat will be produced globally by 2025. This surplus, enhances the need for diversification of milk fat products and the milk pool in general. Infant milk formula producers, for instance, have incorporated enzyme modified ("humanised") milk fat and fat globule phospholipids to better mimic human milk fat structures. Minor components like mono- and di-glycerides from milk fat are increasingly utilized as emulsifiers, replacing palm esters in premium-priced food products. This review examines the chemistry of milk fat and the technologies employed for its modification, fractionation and enrichment. Emerging processing technologies such as ultrasound, high pressure processing, supercritical fluid extraction and fractionation, can be employed to improve the nutritional and functional attributes of milk fat. The potential of recent developments in biological intervention, through dietary manipulation of milk fatty acid profiles in cattle also offers significant promise. Finally, this review provides evidence to help redress the imbalance in reported associations between milk fat consumption and human health, and elucidates the health benefits associated with consumption of milk fat and dairy products. © 2020, © 2020 Taylor & Francis Group, LLC.

https://doi.org/10.1080/10408398.2020.1778631

Dynamic Mechanical Analysis as a Complementary Technique for Stickiness Determination in Model Whey Protein Powders

O'Donoghue, LT; Haque, MK; Hogan, SA; Laffir, FR; O'Mahony, JA; Murphy, EG

Foods, 2020

The α-relaxation temperatures (Tα), derived from the storage and loss moduli using dynamic mechanical analysis (DMA), were compared to methods for stickiness and glass transition determination for a selection of model whey protein concentrate (WPC) powders with varying protein contents. Glass transition temperatures (Tg) were determined using differential scanning calorimetry (DSC), and stickiness behavior was characterized using a fluidization technique. For the lower protein powders (WPC 20 and 35), the mechanical Tα determined from the storage modulus of the DMA (Tα onset) were in good agreement with the fluidization results, whereas for higher protein powders (WPC 50 and 65), the fluidization results compared better to the loss modulus results of the DMA (Tα peak). This study demonstrates that DMA has the potential to be a useful technique to complement stickiness characterization of dairy powders by providing an increased understanding of the mechanisms of stickiness.

http://dx.doi.org/10.3390/foods9091295

Composition, Fractionation, Techno-Functional Properties and Applications of Milk Fat Globule Membrane–Derived Material

Oliveira, D., O'Mahony, J.A.

Advanced Dairy Chemistry: Vol.2 Lipids, 2020

Milk fat occurs as globules with a non-polar lipid core composed primarily of triglycerides and surrounded by the milk fat globule membrane (MFGM). Because of its cellular membrane origin, the MFGM is the richest source of phospholipids (PLs), glycolipids, gangliosides and glycoproteins in milk. Skimmed milk, buttermilk and butter serum are especially enriched with respect to these components. Due to their origin, structure and original function in stabilising the fat globules in whole milk, MFGM-derived materials are efficient and natural emulsifiers in addition to their health benefits. However, emulsifying properties of these MFGM-derived materials are strongly dependent on their content and profile of polar lipids and proteins, and the utilisation of MFGM to formulate PL-enriched ingredients remains poorly exploited commercially. This chapter aims to compile the available information on MFGM composition, particularly PLs and specific membrane proteins. The influence of the processing steps, the techno-functional properties and potential applications of MFGM-derived material are also discussed.

CareerFIT Publication

https://doi.org/10.1007/978-3-030-48686-0_6

Investigation of an in-line prototype fluorescence and infrared backscatter sensor to monitor rennet-induced coagulation of skim milk at different protein concentrations

Panikuttira B.; Payne F.A.; O'Shea N.; Tobin J.T.; O'Callaghan D.J.; O'Donnell C.P.

International Journal of Food Science and Technology, 2020

Coagulation of milk is one of the most important steps in cheese manufacture. Cutting the coagulum at optimum firmness is important to optimise the yield and quality of the cheese produced. The aim of this study was to investigate a prototype sensor to monitor rennet-induced coagulation of skim milk at different protein concentrations (3.3%, 4.0% and 4.7%) and to develop a model to predict the coagulum cutting time at a desired storage modulus (G′). Fluorescence and infrared backscatter profiles were recorded at wavelengths of 350 and 880 nm, respectively. Rheological measurements were used as a reference method to determine the times required for the coagulum to reach G′ values of 0.5, 5 and 20 Pa. Time parameters extracted from the optical profiles generated during the coagulation process were used to develop a model to predict the cutting time at which the coagulum reaches selected G′ values. This study demonstrated that the investigated prototype sensor, combined with the developed prediction model, can be used as an in-line PAT tool for real-time monitoring of milk coagulation and prediction of cutting time in cheese manufacturing. © 2019 Institute of Food Science and Technology

https://doi.org/10.1111/ijfs.14267

The effects of cow genetic group on the density of raw whole milk

Parmar P.; Lopez-Villalobos N.; Tobin J.T.; Murphy E.; Buckley F.; McDonagh A.; O'Mahony J.A.; Crowley S.V.; Kelly A.L.; Shalloo L.

Irish Journal of Agricultural and Food Research, 2020

The density of milk is dependent upon various factors including temperature, processing conditions, and animal breed. This study evaluated the effect of different cow genetic groups, Jersey, elite Holstein Friesians (EHF), and national average Holstein Friesians (NAHF) on the compositional and physicochemical properties of milk. Approximately 1,040 representative (morning and evening) milk samples (~115 per month during 9 mo) were collected once every 2 wk. Milk composition was determined with a Bentley Dairyspec instrument. Data were analysed with a mixed linear model that included the fixed effects of sampling month, genetic group, interaction between month and genetic group and the random effects of cow to account for repeated measures on the same animal. Milk density was determined using three different analytical approaches – a portable and a standard desktop density meter and 100 cm3 calibrated glass pycnometers. Milk density was analysed with the same mixed model as for milk composition but including the analytical method as a fixed effect. Jersey cows had the greatest mean for fat content (5.69 ± 0.13%), followed by EHF (4.81 ± 0.16%) and NAHF (4.30 ± 0.15%). Milk density was significantly higher (1.0313 g/cm3 ± 0.00026, $P < 0.05$) for the milk of Jersey breed when compared to the EHF (1.0304 ± 0.00026 g/cm3) and NAHF (1.0303 ± 0.00024 g/cm3) genetic groups. The results from this study can be used by farmers and dairy processors alike to enhance accuracy when calculating the quantity and value of milk solids depending upon the genetic merit of the animal/herd, and may also improve milk payment systems through relating milk solids content and density.

http://dx.doi.org/10.15212/ijafr-2020-0115

The effect of compositional changes due to seasonal variation on milk density and the determination of season-based density conversion factors for use in the dairy industry

Parmar P.; Lopez-Villalobos N.; Tobin J.T.; Murphy E.; McDonagh A.; Crowley S.V.; Kelly A.L.; Shalloo L.

Foods, 2020

The objective of this study was to determine the effect of seasonal variation on milk composition and establish an algorithm to predict density based on milk composition to enable the calculation of season-based density conversion calculations. A total of 1035 raw whole milk samples were collected from morning and evening milking of 60 spring-calving individual cows of different genetic groups, namely Jersey, Elite HF (Holstein Friesian) and National Average HF, once every two weeks for a period of 9 months (March November, 2018). The average mean and standard deviation for milk compositional traits were 4.72 ± 1.30% fat, 3.85 ± 0.61% protein and 4.69 ± 0.30% lactose and density was estimated at 1.0308 ± 0.002 g/cm3. The density of the milk samples was evaluated using three methods: a portable density meter, DMA 35; a standard desktop version, DMA 4500M; and an Association of Official Agricultural Chemists (AOAC) method using 100-mL glass pycnometers. Statistical analysis using a linear mixed model showed a significant difference in density of milk samples ($p < 0.05$) across seasonal and compositional variations adjusted for the effects of days in milk, parity, the feeding treatment, the genetic group and the measurement technique. The mean density values and standard error of mean estimated for milk samples in each season, i.e., spring, summer and autumn were 1.0304 ± 0.00008 g/cm3, 1.0314 ± 0.00005 g/cm3 and 1.0309 ± 0.00007 g/cm3, respectively.

http://dx.doi.org/10.3390/foods9081004

Novel application of confocal Raman microscopy to determine the microstructure of fermented dairy products including the spatial distribution of proteins, lipids and carbohydrates

Pax, A.P.; Sheehan, J.J.

Biomedical Spectroscopy and Imaging, 2020

Background:

The distribution of components in fermented dairy products forms the microstructure which influences final product texture and taste. Confocal Raman microscopy may provide new molecular information on product structure not possible with other advanced microscopy techniques.

Objective:

Dairy products including non-fat and full fat yoghurt, Camembert and Cheddar cheese samples were surveyed and the product microstructure observed using confocal Raman microscopy in order to determine the applicability of the technique to dairy product analysis.

Methods:

Confocal Raman microscopy provided spatially resolved chemical information on the components of fermented dairy products. In conjunction with component analysis and exploratory data analysis, spatially resolved chemical information on the components of fermented dairy products was obtained and compared.

Results:

Yoghurts with differing fat levels displayed different microstructures, consistent with other techniques. The influence of different molecular structures on the Camembert cheese centre and surface was revealed and Raman microscopy also gave new insights on the chemical structures within Cheddar cheese.

Conclusions:

The method provides a new technique for observing the contribution of different components to the product microstructure that may be used to monitor product quality and guide product development.

CareerFIT Publication

https://10.3233/BSI-200201

Assessment of a solid-state bulk acoustic wave sensor to measure viscosity of Newtonian and Non-Newtonian fluids under static and flow conditions

Pu Y.; O'Shea N.; Hogan S.A.; Tobin J.T.

Journal of Food Engineering, 2020

Monitoring and control of inline viscosity is crucial for process optimisation and for ensuring a high quality final product but currently this parameter is still under-utilised in the dairy industry. This study investigated a solid-state bulk acoustic wave sensor to measure the viscosity of Newtonian (oil standards) and Non-Newtonian fluids (reconstituted skim milk (RSM) at different concentrations) under static (off-line measurements) and flow conditions (in-line measurements). Results illustrated that an increase in total solids (TS) of RSM gave an increase in acoustic viscosity. Non-linear regression was applied to the experimental data to successfully transform the acoustic viscosity outputs into commonly-used reference viscosity values. RSM at higher TS presented a non-Newtonian behaviour and demonstrated shear-thinning properties. Under flow conditions the viscosity of the RSM decreased as a result of shearing experienced in the pipe. This study demonstrated the potential of an acoustic wave sensor to measure in-line viscosity in dairy applications. © 2020 Elsevier Ltd

https://doi.org/10.1016/j.jfoodeng.2020.109917

Review of near-infrared spectroscopy as a process analytical technology for real-time product monitoring in dairy processing

Pu Y.-Y.; O'Donnell C.; Tobin J.T.; O'Shea N.

International Dairy Journal, 2020

Real-time process/product monitoring can be achieved using suitable process analytical technologies (PAT) to improve process efficiencies and product quality. In the dairy industry, near infrared (NIR) spectroscopy has been utilised as a laboratory analytical method (off-line) for compositional analysis of dairy products since the 1970s. Recent advances in NIR technology and instrumentation have widened its applications from a bench-top analytical instrument to a promising PAT tool for on-line and in-line implementation. This review focuses on the use of NIR technology for real-time monitoring of dairy products, by briefly outlining the measurement principle, NIR instrument configurations, in-line sampling methods, calibration models development, some practical considerations for process installation, and current state of the art in on-line and in-line NIR applications (2012 to date) for continuous process monitoring in the production of dairy products. The challenges and additional resources required to improve production efficiencies using NIR spectroscopy are also discussed. © 2019 Elsevier Ltd

http://dx.doi.org/10.1016/j.idairyj.2019.104623

Influence of Processing Temperature on Membrane Performance and Characteristics of Process Streams Generated during Ultrafiltration of Skim Milk

Puri, R., Singh, U., O'Mahony, J.A.

Foods, 2020

The effects of processing temperature on filtration performance and characteristics of retentates and permeates produced during ultrafiltration (UF) of skim milk at 5, 20, and 50 °C were investigated. The results indicate that despite higher flux at 50 °C, UF under these conditions resulted in greater fouling and rapid flux decline in comparison with 5 and 20 °C. The average casein micelle diameter was higher in retentate produced at 5 and 20 °C. The retentate analysed at 5 °C displayed higher viscosity and shear thinning behaviour as compared to retentate analysed at 20 and 50 °C. Greater permeation of calcium and phosphorus was observed at 5 and 20 °C in comparison with 50 °C, which was attributed to the inverse relationship between temperature and solubility of colloidal calcium phosphate. Permeation of α-lactalbumin was observed at all processing temperatures, with permeation of β-lactoglobulin also evident during UF at 50 °C. All UF retentates were shown to have plasmin activity, while lower activity was measured in retentate produced at 5 °C. The findings revealed that UF processing temperature influences the physicochemical, rheological, and biochemical properties of, and thereby govern the resulting quality and functionality of, retentate- and permeate-based dairy ingredients.

CareerFIT Publication

https://doi.org/10.3390/foods9111721

Colorants in cheese manufacture: Production, chemistry, interactions, and regulation

Sharma P.; Segat A.; Kelly A.L.; Sheehan J.J.

Comprehensive Reviews in Food Science and Food Safety, 2020

Colored Cheddar cheeses are prepared by adding an aqueous annatto extract (norbixin) to cheese milk; however, a considerable proportion (~20%) of such colorant is transferred to whey, which can limit the end use applications of whey products. Different geographical regions have adopted various strategies for handling whey derived from colored cheeses production. For example, in the United States, whey products are treated with oxidizing agents such as hydrogen peroxide and benzoyl peroxide to obtain white and colorless spray-dried products; however, chemical bleaching of whey is prohibited in Europe and China. Fundamental studies have focused on understanding the interactions between colorants molecules and various components of cheese. In addition, the selective delivery of colorants to the cheese curd through approaches such as encapsulated norbixin and microcapsules of bixin or use of alternative colorants, including fat-soluble/emulsified versions of annatto or beta-carotene, has been studied. This review provides a critical analysis of pertinent scientific and patent literature pertaining to colorant delivery in cheese and various types of colorant products on the market for cheese manufacture, and also considers interactions between colorant molecules and cheese components; various strategies for elimination of color transfer to whey during cheese manufacture are also discussed. © 2019 Institute of Food Technologists®

https://doi.org/10.1111/1541-4337.12519

Application of a cascade membrane filtration process to standardise serum protein depleted cheese milk for cheddar cheese manufacture

Xia, XF; Tobin, JT; Sharma, P; Fenelon, M; McSweeney, PLH; Sheehan, JJ

International Dairy Journal, 2020

A cascade membrane filtration process including microfiltration (MF), ultrafiltration (UF) and reverse osmosis (RO) was used to fractionate skim milk into different streams. Significant quantities of lactose and minerals were removed to permeate after MF at 0.14 μm. Cheese milk, of similar casein content to the raw milk, was standardised simultaneously for casein, lactose, ash and total calcium from the membrane streams without requiring CaCl2 and lactose addition. Serum protein depleted cheese milk of typical casein content had similar rennet coagulability, cheese composition, texture and yield to the control; milk of 1.5 × casein content had a faster coagulation rate and resulted in cheese of lower moisture content. On a dry matter basis, the serum protein content of MF permeate concentrated by UF was significantly higher than that in cheese whey (51.54% versus 5.63–9.45%), with significantly lower contents of ash (0.95% versus 7.11–7.53%) and lactose (9.50% versus 61.98–70.35%).

http://dx.doi.org/10.1016/j.idairyj.2020.104796

Dilute phase pneumatic conveying of whey protein isolate powders: Particle breakage and its effects on bulk properties

Zhang F.; Olaleye A.K.; O'Mahony J.A.; Miao S.; Cronin K.

Advanced Powder Technology, 2020

Breakage of dairy powder during pneumatic conveying negatively affects the end-customer properties (scoop uniformity and reconstitution). A dilute phase pneumatic conveying system was built to conduct studies into this problem using whey protein isolate powder (WPI) as the test material. Effects of conveying air velocity (V), solid loading rate (SL), pipe bend radius (D), and initial particle size (d) on the level of attrition were experimentally studied. Four quality characteristics were measured before and after conveying: particle size distribution, tapped bulk density, flowability, and wettability. The damaged WPI agglomerates after conveying give rise to many porous holes exposed to the interstitial air. V is the most important input variable and breakage levels rise rapidly at higher airspeeds. The mean volume diameter D[4,3] decreased by around 20% using the largest airspeed of 30 m/s. Powder breakage is also very sensitive to particle size. There appears to be a threshold size below which breakage is almost negligible. By contrast, SL and D show lesser influence on powder breakage. Reflecting the changes in particle size due to breakage, tapped bulk density increases whereas wettability decreases as a result of an increase in conveying air velocity. However, breakage does not show a significant effect on powder flowability as powder damage not only decreases particle size but also changes the particle's surface morphology. © 2020 The Society of Powder Technology Japan

https://doi.org/10.1016/j.apt.2020.06.019

Characterization of norbixin and evaluation of its mobility through rennet-induced micellar casein concentrate gels as influenced by an electrical field

Alehosseini A.; Sharma P.; Kelly A.L.; Sheehan J.J.

Innovative Food Science and Emerging Technologies, 2021

In this study, application of an electrical field to facilitate the migration of norbixin molecules through rennet-induced micellar casein concentrate (MCC) and agar gels was evaluated. To determine the effect of selected parameters on norbixin penetration through the renneted casein gels, MCC, as a curd-like structure, was used to simplify the study of the process and evaluate the impact of each parameter on the migration of norbixin molecules separately. The physicochemical properties of norbixin solutions were characterized, followed by evaluation of the effects of changing gel composition on colorant mobility—influenced by an electrical field. Multi-angle dynamic light scattering enabled size measurement of norbixin solutions. A strong negative charge (−53.4 to −73.4 mV) was observed at all pH values examined. Localization of norbixin molecules within the aqueous phase was shown by confocal laser scanning microscopy. Norbixin solutions, characterized by LUMiSizer and light microscopy, showed the formation of aggregates (30–50 μm) in the presence of CaC12. Reducing pH and increasing calcium content considerably decreased norbixin penetration through the gels. The penetration rate of norbixin was considerably reduced (~ 60%) in the presence of 2% of calcium chloride. By reducing the pH from 6.58 to 5.37 and 6.60 to 5.30, the penetration rate of color through the gels containing 7.5 and 15% protein was reduced by ~90 and 80%, respectively. However, as salt concentrations increased (0% to 4%), the penetration rate of the colorant through MCC gels of 15% protein increased by 60%. Overall, this work shows that applying an electrical field is a promising approach which may considerably increase the migration rate of colorant through rennet-induced casein gels. © 2021

https://doi.org/10.1016/j.ifset.2021.102812

A cascade microfiltration and reverse osmosis approach for energy efficient concentration of skim milk

Blais H.; Ho Q.T.; Murphy E.G.; Schroën K.; Tobin J.T.

Journal of Food Engineering, 2021

To improve the efficiency of water removal from skim milk, a cascade membrane process of microfiltration and reverse osmosis (RO) was developed whereby skim milk was concentrated to 18% dry matter (DM) by RO at either 15 or 50 °C. The average flux of the RO process at 50 °C was 89% higher than that observed at 15 °C, linked to altered membrane surface fouling behaviour due to lower viscosity, higher cross-flow velocity and increased diffusivity of the solvent phase. In corollary, a ~57% energy reduction per unit volume of water removed was observed when the RO process was operated at 50 °C. Evaluation of the physicochemical properties of control (9% DM content skim milk) and RO retentates post-heating (at 80, 90 and120 °C) and post-evaporation (to 42% DM) demonstrated a clear relationship between heating at elevated DM contents and solution viscosity, an effect that was compounded at higher heating temperatures. © 2021 Elsevier Ltd

https://doi.org/10.1016/j.jfoodeng.2021.110511

Prevalence of intramammary antibiotic usage in dairy farming

Burke N.; Adley C.C.

Journal of Dairy Research, 2021

This research communication describes the lactating intramammary (IMM) antibiotic formulation most used by Irish dairy farmers at farm level through interviewing 202 dairy farmers. The IMM antibiotic usage data is not easily available to the researcher and farming community. This study determined that three commercial formulations (Synulox ™, Tetra Delta™ and Terrexine) made up 81% of the products used at farm level. The formulation Synulox™ was the most used at 34% first preference and 32% second preference and contains amoxicillin/clavulanic, a standard broad spectrum antibiotic, for which mastitis pathogen resistance remains low. The aminoglycosides were used in four of the IMM formulations analysed, including Tetra Delta™ and Terrexine. Of the 12 antibiotics identified in the IMM formulations studied, three including cefalexin, benzylpenicillin and penethamate are classified as highly important antibiotics (HIA) by the World Health Organisation (WHO) whilst the other 8 (dihydrostreptomycin, streptomycin, neomycin, framycetin, kanamycin, amoxicillin/clavulanic acid, and cefquinome), are considered critically important (CIA) for use in human health. This study has generated knowledge of the preferences of lactating IMM formulations used at farm level.

https://doi.org/10.1017/S0022029921000431

A comparison of analytical test methods in dairy processing

Burke N.; Zacharski K.; Adley C.C.; Southern M.

Food Control, 2021

Dairy quality strategies start at the beginning of a raw milk supply chain at farm level, but it is the obligation of the manufacturer at a dairy processing plant to ensure quality is upheld from intake to finished product. This is achieved by implementing robust quality systems, measured through sampling plans and analytical test methods. Influences on product quality and composition, and analytical test results within a dairy plant are multi-factorial including: seasonality; the quality of incoming milk and herd health; the level of skilled laboratory technicians; the level of production and the availability of equipment; and finally milk harvesting, transportation and handling. These factors, along with customer and regulatory requirements will determine the level and type of analytical testing required. In the dairy industry, manufacturers oftentimes pay little attention to the need for optimising analytical test strategies or improving laboratory operations, if it is not broken why fix it? The focus of this qualitative research was to differentiate the core current analytical test methods in use at three dairy manufacturing plants for the production of raw milk, skim milk and cream and skim milk powder (SMP). The main objective being to inform and educate each producer on best practice methods. Results displayed similarities across testing categories but demonstrated a range of traditional testing methods in the microbiological analysis compared to advanced instrumentation use in the chemical and compositional analytical category. The dairy industry needs to adapt to a modern, process focused quality system using industry 4.0 analytical processing regimes. © 2020 The Authors

https://doi.org/10.1016/j.foodcont.2020.107637

The influence of pre-heat treatment of skim milk on key quality attributes of fat filled milk powder made therefrom

Finnegan E.W.; Mahomud M.S.; Murphy E.G.; O'Mahony J.A.

International Journal of Dairy Technology, 2021

Key quality aspects of fat filled milk powders (FFMPs) produced with skim milk pre-heated at 93 °C × 60 s and 105 °C × 15 s (medium whey protein nitrogen index; WPNI), and 116 °C × 60 s and 136 °C × 15 s (high WPNI) were examined. The 136 °C × 15 s treatment produced a FFMP with threefold higher free fat, showed significantly ($P < 0.05$) lower solubility in coffee and exhibited extensive flecking on rehydration in water. Insoluble materials were observed using microscopy; flecks generated upon rehydration in water were composed of fat, whereas flecks/sediment in coffee were composed of undissolved powder particles.

http://dx.doi.org/10.1111/1471-0307.12758

The influence of temperature on filtration performance and fouling during cold microfiltration of skim milk

France T.C.; Bot F.; Kelly A.L.; Crowley S.V.; O'Mahony J.A.

Separation and Purification Technology, 2021

Changes in the physicochemical properties and distribution of constituents in skim milk during microfiltration (MF) at low temperature influence filtration performance and product composition. In this study, the influence of processing temperature within the cold MF range (4, 8 and 12 °C) on filtration performance, fouling and partitioning of proteins was investigated. MF at 4 °C required the greatest energy input due to the significantly higher ($p < 0.05$) viscosity of feed and retentate streams, compared to processing at 8 and 12 °C. The greatest and lowest extents of reversible and irreversible fouling during MF were observed on filtration at 12 and 4 °C, respectively. Chemical analysis of the cleaning solutions post-processing demonstrated that protein was the major foulant; the lowest protein content in the recovered cleaning solutions (50 °C water and 55 °C alkali) was measured after MF at 4 °C. The concentration of β-casein, β-lactoglobulin and α-lactalbumin in the permeate all decreased throughout MF, due to fouling of the membrane. The greatest decrease in concentration of β-casein in the permeate during MF was observed at 12 °C (18.1%) followed by 8 °C (17.1%) and 4 °C (13.6%). The results of this study provide valuable information on processing efficiency (i.e., energy consumption and protein yield) and membrane fouling during the processing of skim milk in the cold MF range.

http://dx.doi.org/10.1016/j.seppur.2020.118256

Cold microfiltration as an enabler of sustainable dairy protein ingredient innovation

France T.C.; Kelly A.L.; Crowley S.V.; O'mahony J.A.

Foods, 2021

Classically, microfiltration (0.1–0.5 μm) of bovine skim milk is performed at warm temperatures (45–55◦C), to produce micellar casein and milk-derived whey protein ingredients. Microfiltra-tion at these temperatures is associated with high initial permeate flux and allows for the retention of the casein fraction, resulting in a whey protein fraction of high purity. Increasingly, however, the microfiltration of skim milk and other dairy streams at low temperatures (≤20◦C) is being used in the dairy industry. The trend towards cold filtration has arisen due to associated benefits of improved microbial quality and reduced fouling, allowing for extended processing times, improved product quality and opportunities for more sustainable processing. Performing microfiltration of skim milk at low temperatures also alters the protein profile and mineral composition of the resulting processing streams, allowing for the generation of new ingredients. However, the use of low processing temperatures is associated with high mechanical energy consumption to compensate for the increased viscosity, and thermal energy consumption for inline cooling, impacting the sustainability of the process. This review will examine the differences between warm and cold microfiltration in terms of membrane performance, partitioning of bovine milk constituents, microbial growth, ingredient innovation and process sustainability.

http://dx.doi.org/10.3390/foods10092091

The effects of temperature and transmembrane pressure on protein, calcium and plasmin partitioning during microfiltration of skim milk

France T.C.; Kelly A.L.; Crowley S.V.; O'Mahony J.A.

International Dairy Journal, 2021

Dissociation of β-casein from casein micelles at low temperature is exploited in the manufacture of β-casein-enriched ingredients. In this study, the effects of selected temperatures within the cold processing range (4, 8, 12, 16 and 20 °C) and different transmembrane pressures (0.05 and 0.30 bar), on protein, mineral and plasmin partitioning during microfiltration were determined. Significantly higher ($p < 0.05$) total and ionic calcium concentrations were measured in permeate generated at 4 °C under sub-critical flux conditions (0.05 bar) compared with limiting flux conditions (0.30 bar). Under the former, the highest concentration of β-casein in permeate (2.02 mg mL−1) was achieved at 4 °C; however, these conditions also led to the highest plasmin activity (0.023 AMC units mL−1) in permeate. Lower processing temperature and reduced fouling contribute to higher yields of β-casein, although the concomitantly higher plasmin activity may contribute to protein stability challenges during down-stream processing of such permeates. © 2020 Elsevier Ltd

http://dx.doi.org/10.1016/j.idairyj.2020.104930

Influence of chaperone-like activity of caseinomacropeptide on the gelation behaviour of whey proteins at pH 6.4 and 7.2.

Gaspard, S., Sharma, P., Fitzgerald, C., Tobin, J., O'Mahony, J.A., Kelly, A., Brodkorb, A.

FOOD HYDROCOLLOIDS, 2021

The effect of caseinomacropeptide (CMP) on the heat-induced denaturation and gelation of whey proteins (2.5–10%, w/v) at pH 6.4 and 7.2, at a whey protein:CMP ratio of 1:0.9 (w/w), was investigated using differential scanning calorimetry (DSC), oscillatory rheology (90 °C for 20 min) and confocal microscopy. Greater frequency-dependence in the presence of CMP suggested that the repulsive interactions between CMP and the whey proteins affected the network generated by the non-heated whey protein samples. At pH 6.4 or 7.2, CMP increased the temperature of denaturation of β-lactoglobulin by up to 3 °C and increased the gelation temperature by up to 7 °C. The inclusion of CMP strongly affected the structure of the heat-induced whey protein gels, resulting in a finer stranded structure at pH 6.4 and 7.2. The presence of CMP combined with a lower heating rate (2 °C/min) prevented the formation of a solid gel of whey proteins after heating for 20 min at 90 °C and at pH 7.2. These results show the potential of CMP for control of whey protein denaturation and gelation.

CareerFIT Publication

https://doi.org/10.1016/j.foodhyd.2020.106249

Approaches for improving the flowability of high-protein dairy powders post spray drying – A review

Hazlett R.; Schmidmeier C.; O'Mahony J.A.

Powder Technology, 2021

Challenges are commonly encountered in the bulk handling and application of high-protein dairy powders, and are strongly influenced by their poor flowability. Powder flowability can be defined as the ability of a powder to flow under set environmental or processing conditions and it is ultimately determined by the type and extent of interparticle interactions occurring in the bulk powder (e.g., van der Waals and electrostatic interactions). High-protein powders are particularly susceptible to the occurrence of interparticle interactions, resulting in increased cohesive forces being experienced in the bulk powder, thereby reducing powder flowability. This review summarises the major factors responsible for poor flowability in high-protein dairy powders and critiques traditional (e.g., agglomeration) and some of the more relevant novel approaches (e.g., dry- and wet-coating and roller compaction) available for improving the flowability of powders post-spray drying. This review material will be of considerable interest to dairy scientists, technologists and engineers challenged with understanding, predicting and controlling the bulk handling and flowability of high-value dairy protein powders.

http://dx.doi.org/10.1016/j.powtec.2021.03.021

The Production of Bioactive Peptides from Milk Proteins

Kleekayai T.; Cermeño M.; FitzGerald R.J.

Food Engineering Series, 2021

Peptides derived from milk proteins are associated with a range of different bioactivities, e.g., antioxidant, antihypertensive, antidiabetic, immunomodulatory, antimicrobial, opioid properties. Peptides can be released following in vitro enzymatic hydrolysis, fermentation and in vivo digestion approaches, alone or in combination. The release of bioactive peptides (BAPs) from milk proteins by these processes is reviewed herein. Furthermore, the contribution of in silico approaches in the targeted release and identification of BAPs is outlined. Details of bioactive milk protein derived peptide sequences obtained by enzymatic hydrolysis, fermentation, and in vivo digestion, as well as by using in silico approaches are presented. Examples of the application of membrane processing and chromatographic techniques for milk BAP fractionation and enrichment are described. Research on the production and identification of milk-derived BAPs can contribute to a better understanding of the nutritional benefits of dairy product consumption.

https://doi.org/10.1007/978-3-030-55482-8_18

Assessment of the response of indigenous microflora and inoculated Bacillus licheniformis endospores in reconstituted skim milk to microwave and conventional heating systems by flow cytometry

Li F.; Santillan-Urquiza E.; Cronin U.; O'Meara E.; McCarthy W.; Hogan S.A.; Wilkinson M.G.; Tobin J.T.

Journal of Dairy Science, 2021

Heat treatment is one of the most widely used processing technologies in the dairy industry. Its primary purpose is to destroy microorganisms, both pathogenic and spoilage, to ensure the product is safe and has a reasonable shelf life. In this study microwave volumetric heating (MVH) was compared with a conventional tubular heat exchanger (THE), in terms of the effects of each at a range of temperatures (75°C, 85°C, 95°C, 105°C, 115°C, and 125°C) on indigenous microflora viability and the germination of inoculated Bacillus licheniformis endospores in reconstituted skim milk. To assess the heat treatment–related effects on microbial viability, classical agar-based tests were applied to obtain the counts of 4 various microbiological groups including total bacterial, thermophilic bacterial, mesophilic aerobic bacterial endospore, and thermophilic aerobic bacterial endospore counts, and additional novel insights into cell permeability and spore germination profiles post-heat treatment were obtained using real-time flow cytometry (FC) methods. No significant differences in the plate counts of the indigenous microorganisms tested, the plate counts of the inoculated B. licheniformis, or the relative percentage of germinating endospores were observed between MVH- and THE-treated samples, at equal temperatures in the range specified above, indicating that both methods inactivated inoculated endospores to a similar degree (up to 70% as measured by FC and 5 log reduction as measured by plate counting for some treatments of inoculated endospores). Furthermore, increased cell permeability of indigenous microflora was observed by FC after MVH compared with THE treatment of uninoculated skim milk, which was reflected in lower total bacterial count at a treatment temperature of 105°C. This work demonstrates the utility of FC as a rapid method for assessing cell viability and spore inactivation for postthermal processing in dairy products and overall provides evidence that MVH is at least as effective at eliminating native microflora and inoculated B. licheniformis endospores as THE. © 2021 American Dairy Science Association

https://doi.org/10.3168/jds.2020-19875

Effect of temperature on raw whole milk density and its potential impact on milk payment in the dairy industry

Parmar P.; Lopez-Villalobos N.; Tobin J.T.; Murphy E.; Buckley F.; Crowley S.V.; Kelly A.L.; Shalloo L.

International Journal of Food Science and Technology, 2021

The objective of this study was to determine the effect of temperature on whole milk density measured at four different temperatures: 5, 10, 15, and 20 °C. A total of ninety-three individual milk samples were collected from morning milking of thirty-two Holstein Friesian dairy cows, of national average genetic merit, once every two weeks over a period of 4 weeks and were assessed by Fourier transform infrared spectroscopy for milk composition analysis. Density of the milk was evaluated using two different analytical methods: a portable density meter DMA35 and a standard desktop model DMA4500M (Anton Paar GmbH, UK). Milk density was analysed with a linear mixed model with the fixed effects of sampling period, temperature and analysis method; triple interaction of sampling period x analysis method x temperature; and the random effect of cow to account for repeated measures. The effect of temperature on milk density (ρ) was also evaluated including temperature (t) as covariate with linear and quadratic effects within each analytic method. The regression equation describing the curvature and density–temperature relationship for the DMA35 instrument was ρ = 1.0338−0.00017T−0.0000122T2 (R2 = 0.64), while it was ρ = 1.0334 + 0.000057T−0.00001T2 (R2 = 0.61) for DMA4500 instrument. The mean density determined with DMA4500 at 5 °C was 1.0334 g cm−3, with corresponding figures of 1.0330, 1.0320 and 1.0305 g cm−3 at 10, 15 and 20 °C, respectively. The milk density values obtained in this study at specific temperatures will help to address any bias in weight–volume calculations and thus may also improve the financial and operational control for the dairy processors in Ireland and internationally. © 2020 Institute of Food, Science and Technology (IFSTTF)

http://dx.doi.org/10.1111/ijfs.14869

Development and evaluation of a processing sector model for butter manufacture using a mass balance technique at two dairy processing sites

Parmar P.; Lopez-Villalobos N.; Tobin J.T.; Murphy E.; Crowley S.V.; Kelly A.L.; Shalloo L.

International Journal of Dairy Technology, 2021

The butter manufacturing process at two different commercial dairy processing sites in Ireland was evaluated using a mass balance approach to develop, evaluate and validate a processing sector model of the flow of milk fat from intake to final product. The mass balance was represented as a function of fat intake = fat in products + fat losses + recycled fat. Representative samples of all products, namely whole milk, cream, skim milk, butter, buttermilk and cleaning-in-place streams (cream silo flush, butter churn residue and sludge), were collected from two different sites. Milk fat levels and product quantities were measured to obtain the fat outputs. Total fat losses at the end of butter production ranged between 1.90% and 2.25% of the total fat input for both sites. Three different scenarios were examined to evaluate the model: S1 (Animal Breed) high genetic merit (Elite) and national average (NA) Holstein Friesian (HF) cows were evaluated, for their effect on the net value of milk; S2 (Product Portfolio) a mixed product portfolio of cheese, butter and skim milk powder (SMP) was compared to a product portfolio comprised of butter alone; and S3 (Process Efficiency) the impact of varying process losses on net values of milk and the quantities of products produced was simulated. The value per 1000 L of milk for S1 was €410.69 and €393.20 for Elite and NA cow's milk, respectively. For S2, the butter-only product portfolio returned €355.10, whereas the mixed-products portfolio returned €369.60. Lastly, S3 corresponding returns for 1%, 2.2% and 5% losses was €365.90, €361.47 and €351.12, respectively.

http://dx.doi.org/10.1111/1471-0307.12737

Influence of transglutaminase crosslinking on casein protein fractionation during low temperature microfiltration

Puri R.; Bot F.; Singh U.; O'mahony J.A.

Foods, 2021

CareerFIT Publication

https://doi.org/10.3390/foods10123146

Influence of transglutaminase crosslinking on casein protein fractionation during low temperature microfiltration

Puri, R., Bot, F., Singh, U., O'Mahony, J.A.

Foods, 2021

Low temperature microfiltration (MF) is applied in dairy processing to achieve higher protein and microbiological quality ingredients and to support ingredient innovation; however, low temperature reduces hydrophobic interactions between casein proteins and increases the solubility of colloidal calcium phosphate, promoting reversible dissociation of micellar β-casein into the serum phase, and thus into permeate, during MF. Crosslinking of casein proteins using transglutaminase was studied as an approach to reduce the permeation of casein monomers, which typically results in reduced yield of protein in the retentate fraction. Two treatments (a) 5 °C/24 h (TA) and (b) 40 °C/90 min (TB), were applied to the feed before filtration at 5 °C, with a 0.1 µm membrane. Flux was high for TA treatment possibly due to the stabilising effect of transglutaminase on casein micelles. It is likely that formation of isopeptide bonds within and on the surface of micelles results in the micelles being less readily available for protein-protein and protein–membrane interactions, resulting in less resistance to membrane pores and flow passage, thereby conferring higher permeate flux. The results also showed that permeation of casein monomers into the permeate was significantly reduced after both enzymatic treatments as compared to control feed due to the reduced molecular mobility of soluble casein, mainly β-casein, caused by transglutaminase crosslinking.

CareerFIT Publication

https://doi.org/10.3390/foods10123146

The impact of protein standardisation with liquid or powdered milk permeate on the rheological properties of skim milk concentrates

Tsermoula P.; Drapala K.P.; Joyce A.M.; Hoare K.; Crowley S.V.; O'Mahony J.A.

International Dairy Journal, 2021

The objective of this study was to determine the effect of mineral addition during standardisation on colloidal and rheological properties of skim milk on concentration. For that purpose, solubility, ionic strength and ionic calcium activity of milk permeate were determined and skim milk was standardised with either lactose or milk permeate (in powder or reconstituted form). Results indicated that milk permeate contains mineral complexes that alter the ionic equilibrium of skim milk and standardisation with permeate powder has the potential to decrease casein micelle size and integrity. Apparent viscosity of the concentrates demonstrated that skim milk standardised with milk permeate powder had the highest viscosity, followed by that standardised with reconstituted milk permeate or lactose. These novel results demonstrate that the physical state of minerals in milk permeate influence the physicochemical properties of skim milk and thereby affect viscosity of resultant concentrates.

http://dx.doi.org/10.1016/j.idairyj.2021.104982

Effect of thermal treatment on serum protein reduced micellar casein concentrate: An evaluation of rennet coagulability, cheese composition and yield

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International Dairy Journal, 2021

Microfiltration at 0.10 μm removed ~70.29% of serum proteins from milk and the resultant micellar casein concentrates (MCC) were subjected to no heat treatment (control), pasteurisation (72 °C × 15 s) and high heat treatment (HHT; 90 °C × 15s) before formulation of cheese milk for Cheddar cheese manufacture. MCC showed good heat stability due to low serum protein content. For cheese milk of typical casein content, both pasteurisation and HHT did not significantly influence pH, calcium distribution and rennet coagulability, or subsequent cheese composition and yield; although HHT elongated cheese make time significantly. On increasing casein content from 3.09% to 4.31%, there was no significant difference for rennet to cut time between cheeses made from milk with different thermal histories and casein contents. Overall, HHT of MCC had no significant impact on cheese make properties, cheese composition and yield of Cheddar cheese.

http://dx.doi.org/10.1016/j.idairyj.2020.104902

A preliminary evaluation of the impact of pulsed electric field and high-pressure processing treatments on mobility of norbixin molecules through rennet-induced casein matrices

Alehosseini A.; Wall C.; Segat A.; Tiwari B.K.; Sharma P.; Kelly A.L.; Sheehan J.J.

Journal of Food Process Engineering, 2022

Considering the turnover of global cheese industry and while colored cheese is a subset of this, the issue of producing colored cheese without compromising the quality and economic value of the whey stream is a significant one. In this work, the potential of two pilot-scale processes—pulsed electric field (PEF) and high-pressure processing (HPP)—to increase the diffusion rate of norbixin molecules through a casein model system, rennet-induced micellar casein concentrate, and Cheddar cheese, were evaluated independently. Varying PEF treatments (2.4 kV cm−1, pulse widths: 5–7 μs) were applied to alter the degree of sample permeabilization; however, the migration patterns of norbixin molecules were not statistically affected. Cheddar cheese samples were also subjected to high pressure (HP) treatments (250–400 MPa, 10 min). Confocal laser scanning micrographs of the HP-treated samples showed more distinct spherical fat globules surrounded by the continuous protein phase, suggesting HP-treatment considerably assists hydration of the protein phase and induces the distinctive fat mass appearance. However samples L*, a*, and b* color values were not altered significantly other than minor colorant diffusion through surface crevices. While the operational parameters, at the range applied in this work, did not significantly increase the penetration rate of norbixin through the samples, the resulting findings do significantly add to the current knowledge and through further research should considerably shorten the path to achieving a practical solution. Practical Applications: The two industrially scalable approaches (i.e., PEF and HPP) that have been evaluated in the current research have not previously been applied to increase the migration of norbixin molecules through the renneted casein structure. Furthermore, the application of PEF to cheeses is one in which interest is now growing. The current authors believe that the current study has a high degree of commercial importance and could be used as a catalytic study for further research around manipulating the relevant parameters and optimizing the process, so that PEF and HPP can finally be used at industrial scale. © 2021 Wiley Periodicals LLC.

https://dx.doi.org/10.1111/jfpe.13935

Impact of thermal inactivation conditions on the residual proteolytic activity and the viscosity properties of whey protein concentrate enzymatic hydrolysates

Amigo-Benavent M.; FitzGerald R.J.

Food Hydrocolloids, 2022

The rationale for enzymatically hydrolysis of whey proteins includes enhancement of their technofunctional properties and the release of bioactive peptide sequences. This study investigated the impact of thermal treatments, i.e., heating using a water bath, using a tubular heat exchanger and heating during spray drying, on the residual proteolytic activity (RA), apparent viscosity (ηapp) and gelation temperature (Tg) of whey protein concentrate hydrolysates (WPH) generated with Alcalase® (WPH-Alc), Neutrase™ (WPH-Neu) and Debitrase® (WPH-Deb). The WPHs generated showed different degrees of hydrolysis (DH, 2.60–11.13%) and chromatographic profiles. Thermal inactivation studies showed different impacts on RA dependent on the thermal treatment conditions. The ηapp of unheated WPHs were significantly lower (16–18%) than that of the unhydrolysed whey protein concentrate (WPC). Thermal inactivation (80 °C waterbath) increased ηapp of all samples producing aggregates. Tubular heat exchanger inactivation increased ηapp of WPH-Alc and WPH-Deb at different rates, whereas no significantly changes were observed for WPH-Neu for holding times lower than 10 min. At 45% (w/v) total solids (TS) the viscosity of WPC was 1.0 Pa s, whereas the equivalent viscosity for WPC -Alc and WPH-Deb was achieved at 49.5 and 50.1% TS. Different trends were observed in Tg of the WPHs which were dependent on the enzyme and thermal treatment. Overall, this study demonstrates that judicious choice of thermal treatments during WPH enzyme inactivation is required in order to achieve an appropriate balance between RA, ηapp and Tg. © 2021 Elsevier Ltd

http://dx.doi.org/10.1016/j.foodhyd.2021.107333

Biofunctional, structural, and tribological attributes of GABA-enriched probiotic yoghurts containing Lacticaseibacillus paracasei alone or in combination with prebiotics

Garavand F.; Daly, David F.M.; Gómez-Mascaraque, Laura G.

International Dairy Journal, 2022

This study investigated some biofunctional, structural, and tribological attributes of synbiotic yoghurts produced using Lacticaseibacillus paracasei as probiotic, and galactofructose, inulin, soy protein isolate, and spirulina as prebiotics. The highest gamma-aminobutyric acid (GABA) production (99.63 μg mL−1) and glutamic acid consumption (98.39 μg mL−1) was found in spirulina-supplemented probiotic yoghurts (YSP), followed by galactofructose-supplemented probiotic yoghurts (YGF). However, YSP exhibited the lowest probiotic viability and the greatest pH drop. The biological activity of YSP, in terms of total phenolics, antioxidant potential, antihypertensive activity, and degree of hydrolysis was significantly higher than the other yoghurts. YSP showed lower friction coefficient in the high sliding velocities compared with other yoghurt samples. The best appearance and mouthfeel was rated by panellists for YSP, while the taste, texture, and overall acceptance of other yoghurts were preferred. Overall, the synbiotic yoghurts containing spirulina, and galactofructose represent a promising strategy for development of functional dairy products.

CareerFIT Publication

https://doi.org/10.1016/j.idairyj.2022.105348

Impact of total calcium in milk protein concentrate on its interaction with the aqueous phase

Khalesi, Mohammadreza; FitzGerald, Richard J.

Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2022

The impact of calcium level in milk protein concentrate (MPC80) containing 80% protein on its interaction with the aqueous phase was investigated. Partial acidification (pH 6.0) together with cation exchange processing was employed to modify the mineral content of control MPC (CMPC, having 2.87% (w/w) calcium) to yield MPCs with medium (1.57% w/w), low (1.00% w/w) and very low (0.36% w/w) calcium contents, namely MPCF1, MPCF2 and MPCF3, respectively. The total protein contents of CMPC, MPCF1, MPCF2 and MPCF3 was 85.58, 82.01, 81.27 and 79.50 (%, w/w), respectively, while their undenatured whey protein (WP) contents were 6.03, 4.97, 4.62 and 3.51 g/100 g overall protein, respectively. The mineral profiles on the powder particle surfaces of the different MPCs was determined using X-ray photoelectron spectroscopy (XPS). The surface calcium and sodium contents of CMPC and MPCF3 were 0.3% and 0.0%, and 0.2% and 0.4% atomic concentration, respectively. Technofunctional property analysis showed that MPCF2 had the highest water holding capacity (3.40 g water/g protein) among the calcium reduced MPCs. The overall solubility following centrifugation of 5% (w/v, on a protein basis) aqueous reconstituted CMPC (65.82%), MPCF1 (76%), MPCF2 (83%) and MPCF3 (97%) was determined. Furthermore, nitrogen solubility for 4% (w/v, on a protein basis) aqueous suspensions at pH 4.0, 7.0 and 10.0 showed that all samples had low solubility at pH 4.0 ranging from 10% to 22%. Complete solubility was observed at pH 7.0 for MPCF2 and MPCF3 while the solubility of MPCF1 and CMPC at this pH was 77% and 85%, respectively. Complete solubility of all MPC80 samples was observed at pH 10. In conclusion, partial acidification followed by cation exchange chromatography led to the production of MPC80s with different calcium levels. These MPC80 ingredients displayed different powder particle surface compositions and had different interactions with the aqueous phase. Targeted modification of mineral/calcium content may be employed to generate MPC ingredients with different surface properties and functionalities.

CareerFIT Publication

https://doi.org/10.1016/j.colsurfa.2021.128068

Impact of variation in calcium level on the technofunctional properties of milk protein concentrate

Khalesi, Mohammadreza; FitzGerald, Richard J.

Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2022

The technofunctional properties of milk protein concentrate containing 80% protein (MPC80) with different calcium contents, i.e., MPCF1, MPCF2 and MPCF3 contained 1.57%, 1.00% and 0.36% calcium, respectively, were studied. The MPC samples with reduced calcium were produced using partial acidification followed by a cation exchange process thereby replacing calcium with sodium in an MPC80 concentrate. Scanning electron microscopy analysis of MPC80 powder particles showed that the MPCF3 powder particles were more spherical than the other samples. The MPCF3 sample had the highest emulsion stability, apparent viscosity (ηapp) and thermal stability (during heating between 110 and 140 °C). The results showed that modification of the calcium content in MPC80 using cation exchange significantly altered its microstructure, particle size distribution, apparent viscosity, thermal stability, colour properties, oil binding capacity and emulsion stability.

CareerFIT Publication

https://doi.org/10.1016/j.colsurfa.2022.128741

Chromatographic Techniques to Separate and Identify Bioactive Compounds in Microalgae

Kiani H.; Aznar R.; Poojary M.M.; Tiwari B.K.; Halim R.

Frontiers in Energy Research, 2022

Microalgae are potential sources for the sustainable production of valuable chemicals including polyphenols, pigments, and ω-3 PUFAs. However, successful exploitation of these high value compounds in the food, healthcare and pharmaceutical sectors depends greatly on their effective separation, identification, and analysis after recovery from the biomass. The findings of this review paper illustrated that chromatographic methods coupled to different types of detectors have been used as a crucial part of research on microalgal polyphenols, Omega-3 Polyunsaturated Fatty Acids (ω-3 PUFAs), and pigments production through identification, measurement, sample preparation, and purification practices. Therefore, it is important to provide a comprehensive review regarding the current research in the field. The basic operating principles, parametric optimisation and detection units of common (liquid chromatography and gas chromatography) and novel chromatographic techniques (counter current chromatography, expanded bed adsorption chromatography and supercritical fluid chromatography) used to separate, identify, and quantify polyphenols, PUFAs and pigments from microalgae matrices are comprehensively reviewed.

CareerFIT Publication

https://doi.org/10.3389/fenrg.2022.904014

Effect of pasteurisation and foaming temperature on the physicochemical and foaming properties of nano-filtered mineral acid whey

Purwanti, Nanik; Hogan, Sean A.; Maidannyk, Valentyn A.; Mulcahy, Shane; Murphy, Eoin G.

International Dairy Journal, 2022

Foaming can pose a major challenge during processing of acid whey (AW). In this study, nano-filtered mineral AW was collected from a commercial plant before (AW0) and after pasteurisation (AWpast; 75 °C, 15 s). Both AW samples were foamed at 21 °C and in addition, AWpast was foamed at 61 °C, corresponding to the temperature of in-plant foaming. Physicochemical, foaming, and surface properties of AW samples were compared. Foaming at 21 °C resulted in less pronounced foam characteristics for AWpast compared with AW0. Pasteurisation was found not to significantly affect physicochemical properties; however, interfacial kinetics during foaming were altered, which affected foaming behaviour. Foaming of AWpast at 61 °C produced more stable, “dry” foams. FTIR spectra confirmed the influence of protein unfolding at elevated temperatures on foaming, which was reversible upon cooling. This is significant as it gives processors a mean of controlling foaming through temperature control, where possible.

CareerFIT Publication

https://doi.org/10.1016/j.idairyj.2022.105419

ADSA Foundation Scholar Award: Materials science approach to the study of mechanical and diffusion properties in cheese

Sharma P.

Journal of Dairy Science, 2022

Dairy products can be manufactured in a variety of structural forms (e.g., liquid, semi-solids, and solids). Although liquid milk is a colloidal dispersion of fat and protein in the serum portion, it can easily be converted into a soft gel (yogurt) upon acid coagulation. Similarly, cheese, a rennet-coagulated, casein-rich fraction of milk, falls in the category of semi-solid foods. Structurally, all of these materials are complex in nature because of interactions between protein, fat, and water components. The structural origin of these diversified food textures is derived from the way that various food constituents are arranged to form a unique body or mass. Food materials science helps in the assessment of structural arrangements of these molecules at various length scales. This article focuses on the use of various materials science approaches for understanding the fundamental relationship between process, structure, and property in solving critical issues that pertain to the dairy industry and academia.

https://doi.org/10.3168/jds.2021-21093

Application of a dairy-based model system for mathematical mapping of diffusion of salt within rennet induced micellar casein concentrate matrices

Alehosseini, A., Sharma, P., Sheehan, J.

Journal of Food Engineering, 2023

Salt migration or heterogeneity within cheese blocks influences ripening and quality parameters. A finite element model, based on the unidirectional mass transfer and Fick's second law, was employed to study the influence of changing brining conditions on the diffusion coefficients of salt through rennet-induced micellar casein concentrate model systems. Increasing the calcium ion (0–0.5% w/w) and protein (7.5–15% w/w), concentrations along with decreasing salting temperature (40-10 °C) and pH levels (5.10–6.50), significantly increased salt penetration where the diffusion coefficients ranged from about 1.40 × 10−10 to 8.70 × 10−10 (m2 s−1). Microscopic images revealed considerable changes to the homogeneity of protein structures, wall thickness of the casein-based network channels, and levels of dead-end structures—caused by manipulating the brining conditions. Computational 3D-maps were also prepared using the simulation software to illustrate salt migration. Overall, this study showed the potential for varying specific physicochemical parameters on controlling the migration rate of salt in dairy matrices.

CareerFIT Publication

https://doi.org/10.1016/j.jfoodeng.2022.111263

Non-thermal Processing of Foods: Recent Advances

Bhavya, M.L., Hebbar, H.U.

Food Engineering Series, 2023

Non-thermal processing is gaining immense popularity in food processing, as it has several advantages over thermal processing and potential to be employed in several food processing operations. The food industry is focusing on minimal or mild processing of foods which helps to address issues related to safety, with no or minimum effect on product quality to meet the growing demands of health-conscious consumers. In this regard, the advanced technologies/techniques like high pressure processing, cold plasma, light-based processing, ultrasound, membrane processing etc., have been either employed for select applications or attempted, mainly for microbial load reduction. Although, a couple of these technologies have been employed at industrial levels, there are many issues to be addressed to widen the scope of application. Detailed studies are needed in these areas to address specific issues. However, a few of the techniques are still at laboratory scale or limited to academic studies, though, the results are promising and showed potential for scale-up and commercialization. The understanding of mechanism of action of these techniques, process intervention requirements to enhance efficacy and also limitations of techniques are to be clearly taken note while expanding the scope of application. This chapter mainly focuses on critical findings of various reports, especially the recent ones, on application of novel technologies/techniques for microbial load reduction and product quality, physicochemical parameters, sensorial attributes etc.

CareerFIT Publication

https://doi.org/10.1007/978-3-031-30683-9_6

State of the art and prospects of zeolites and metal organic frameworks (MOFs) for nitrogen and phosphorus removal in dairy wastewater

Bouanga Boudiombo J.S.; Madden D.G.; Cusack B.; Cronin P.; Ryan A.

Chemosphere, 2023

Water is an essential resource for humans, animals, and plants. Water is also necessary for the manufacture of many products such as milk, textiles, paper, and pharmaceutical composites. During manufacturing, some industries generate a large amount of wastewater containing numerous contaminants. In the dairy industry, for each litre of drinking milk produced, about 10 L of wastewater is generated. Despite this environmental footprint, the production of milk, butter, ice cream, baby formula, etc., are essential in many households. Common contaminants in dairy wastewater include high biological oxygen demand (BOD), chemical oxygen demand (COD), salts as well as nitrogen and phosphorus derivatives. Nitrogen and phosphorus discharges are one of the leading causes in the eutrophication of rivers and oceans. Porous materials have long held significant potential as a disruptive technology for wastewater treatment. However, thus far they have been understudied for use in dairy wastewater treatment. Ordered porous materials, such as zeolites and metal organic frameworks (MOFs), represent classes of porous materials with significant potential for the removal of nitrogen and phosphorus. This review explores the different zeolites and MOFs applied in the removal of nitrogen and phosphorus from wastewater and the prospect of their potential for use in wastewater management in the dairy industry. © 2023 Elsevier Ltd

https://doi.org/10.1016/j.chemosphere.2023.138531

Association between the Presence of Resistance Genes and Sanitiser Resistance of Listeria monocytogenes Isolates Recovered from Different Food-Processing Facilities

Cheng, Y., Mousavi, Z., Pennone, V., Hurley, D., Butler, F.

Microorganisms, 2023

Sanitisers are widely used in cleaning food-processing facilities, but their continued use may cause an increased resistance of pathogenic bacteria. Several genes have been attributed to the increased sanitiser resistance ability of L. monocytogenes. This study determined the presence of sanitiser resistance genes in Irish-sourced L. monocytogenes isolates and explored the association with phenotypic sanitiser resistance. The presence of three genes associated with sanitiser resistance and a three-gene cassette (mdrL, qacH, emrE, bcrABC) were determined in 150 L. monocytogenes isolates collected from Irish food-processing facilities. A total of 23 isolates contained bcrABC, 42 isolates contained qacH, one isolate contained emrE, and all isolates contained mdrL. Additionally, 47 isolates were selected and grouped according to the number and type of resistance genes, and the minimal inhibitory concentration (MIC) of these isolates for benzalkonium chloride (BAC) was determined experimentally using the broth microdilution method. The BAC resistance of the strain carrying the bcrABC gene cassette was significantly higher than that of strains lacking the gene cassette, and the BAC resistance of the strain carrying the qacH gene was significantly higher than that of strains lacking the qacH gene ($p < 0.05$). Isolates harbouring both the qacH and bcrABC genes did not show higher BAC resistance. With respect to environmental factors, there was no significant difference in MIC values for isolates recovered from different processing facilities. In summary, this investigation highlights the prevalence of specific sanitiser resistance genes in L. monocytogenes isolates from Irish food-processing settings. While certain genes correlated with increased resistance to benzalkonium chloride, the combination of multiple genes did not necessarily amplify this resistance.

CareerFIT Publication

https://doi.org/10.3390/microorganisms11122989

Influence of processing temperature on plasmin activity and proteolysis in process streams from cold microfiltration of skim milk

France T.C.; Kelly A.L.; Crowley S.V.; O'Mahony J.A.

International Dairy Journal, 2023

Plasmin in process streams derived from microfiltration of skim milk can result in casein hydrolysis, potentially affecting the quality and functionality of ingredients produced. To determine whether partitioning of plasmin into permeates was impacted by processing temperature, cold microfiltration of skim milk was investigated at 4, 8 and 12 °C. Permeate generated at 4 °C had the highest plasmin activity (0.0185 AMC units mL−1). When plasmin activity was expressed relative to β-casein content, differences in the extent of dissociation of β-casein, at the different processing temperatures, did not influence plasmin activity in the resulting permeate streams. Throughout storage at 37 °C, all retentates exhibited extensive plasmin-mediated hydrolysis of β- and αS2-casein; αS1-casein to a lesser extent. Particle size measurements before and after plasmin-mediated hydrolysis of permeates indicated that the proteolysis products of β-casein, γ-caseins, retained the ability to self-associate on heating, with particle size increasing with increasing temperature. © 2023

http://dx.doi.org/10.1016/j.idairyj.2023.105590

Technological solutions and adaptive processing tools to mitigate the impact of seasonal variations in milk composition on Cheddar cheese production—A review

Galli B.D.; Hamed A.M.; Sheehan J.J.; King N.; Abdel-Hamid M.; Romeih E.

International Journal of Dairy Technology, 2023

Variability in milk composition and physicochemical properties impact both manufacturing process performance and the end-use functionality of cheese. Such variability may be attributed to seasonal calving patterns, production systems, breed, weather patterns, and feed type and significantly impacts concentrations of macro- and microconstituents and ultimately cheese composition and quality. This article reviews technological approaches (e.g., milk standardisation protocols and calcium addition), and predictive strategies (e.g., predictive models for coagulation and curd cutting time, in-line sensors), used to mitigate the effects of seasonal changes in milk composition and their impact on process efficacy and functionality in Cheddar cheese manufacturing.

https://doi.org/10.1111/1471-0307.12951

The consequence of supplementing with synbiotic systems on free amino acids, free fatty acids, organic acids, and some stability indexes of fermented milk

Garavand F.; Daly, David F.M.; Gómez-Mascaraque, Laura G.

International Dairy Journal, 2023

An investigation on the impacts of different prebiotics (inulin, galactofructose, soy protein isolate (SPI), and spirulina) and co-culturing with Lacticaseibacillus paracasei on the biological metabolites [free amino acids (FAAs), free fatty acids (FFAs), and organic acids] and stability parameters of fermented milk is presented. All fermented milks represented an increased FAA content compared with their milk counterparts, while the synbiotic fermented milk supplemented with galactofructose (YGF) and spirulina (YSP) were more efficient in this regard. The total organic acid content of the samples was not significantly affected by the type of prebiotics, and co-culturing by L. paracasei, YGF and YSP presented a different pattern, with the highest succinic acid (0.77 mm) and oxoglutaric acid (0.27 mm) contents, respectively. The thermal stability of the fermented milks did not change by loading various prebiotics and co-culturing, while the phase, colloidal, mechanical, and shear stability indexes were significantly affected.

CareerFIT Publication

https://doi.org/10.1016/j.idairyj.2022.105477

Improving the physical and wettability properties of skim milk powders through agglomeration and lecithination

Hailu, Y., Maidannyk, V., Murphy, E., McCarthy, N.

Journal of Food Engineering, 2023

This study aimed to reduce the bulk density of skim milk powders (SMP) and improve subsequent wettability and dissolution by a combination of agglomeration and lecithination. Agglomeration significantly increased powder particle size from a D90 of 120–201 μm, and decreased tapped bulk density (0.73–0.65 g/cm3), although it led to increased friability (32.7%) compared to regular SMP (22.9%). Spraying lecithin on to SMP in the fluid bed improved wettability (8.94 s) compared to regular SMP (>300 s). Agglomeration without lecithination had no effect on powder wettability, similarly, adding lecithin in to liquid skim milk concentrate prior to drying did not improve subsequent powder wettability. Overall, improving the functionality of skim milk is quite complex, and while powder bulk density can be reduced by agglomeration, the particles remain susceptible to breakdown, and the wettability is relatively poor, although this can be improved by spraying lecithin directly on to the powder particles.

CareerFIT Publication

https://doi.org/10.1016/j.jfoodeng.2023.111597

Contribution of whey protein denaturation to the in vitro digestibility, biological activity and peptide profile of milk protein concentrate

Khalesi, Mohammadreza; Cermeño, Maria; FitzGerald, Richard J.

Journal of Functional Foods, 2023

The impact of whey protein (WP) denaturation on the in vitro digestibility and biological activity of milk protein concentrate-85 (MPC85) was investigated. MPC85S1 and MPC85S2 having undenatured WP levels equal to 16.6 and 6.0 g/100 g overall protein, respectively, had similar in vitro protein digestibility corrected amino acid scores equal to 1.14. The samples were subjected to in vitro simulated gastrointestinal digestion while sampling was performed every 30 min during gastric (GD) followed by intestinal (GID) digestion. Liquid chromatography–mass spectroscopy showed that MPC85S1-GD, MPC85S2-GD, MPC85S1-GID and MPC85S2-GID had 50, 38, 47 and 66 unique peptides, respectively. The degree of hydrolysis, molecular mass distribution, dipeptidyl peptidase-IV inhibition, oxygen radical absorbance capacity and 2,2′ -azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) radical scavenging activity of the digests were compared. Overall, the results showed higher digestibility and bioactivities for low-denatured MPC85 compared to high-denatured MPC85 upon GD, however, following GID, both samples were digested to a similar extent.

CareerFIT Publication

https://doi.org/10.1016/j.jff.2023.105543

Draft Genome Sequences of Bacillus licheniformis and Bacillus paralicheniformis Strains Isolated from Irish Skim Milk Powder

Lourenco A.; Li F.; Quijada N.M.; Duffy G.; Tobin J.T.; Butler F.; Jordan K.; O'Brien T.

Microbiology Resource Announcements, 2023

Nineteen Bacillus licheniformis strains and four strains of the closely related species Bacillus paralicheniformis were isolated from a variety of Irish medium-heat skim milk powders. The draft genome sequences of these 23 isolates provide valuable genetic data for research work relevant to dairy products and process development. The isolates are available at Teagasc. © Crown copyright 2023.

https://dx.doi.org/10.1128/mra.00137-23

Cronobacter Species in the Built Food Production Environment: A Review on Persistence, Pathogenicity, Regulation and Detection Methods

Mousavi, Z.E., Hunt, K., Koolman, L., Butler, F., Fanning, S.

Microorganisms, 2023

The powdered formula market is large and growing, with sales and manufacturing increasing by 120% between 2012 and 2021. With this growing market, there must come an increasing emphasis on maintaining a high standard of hygiene to ensure a safe product. In particular, Cronobacter species pose a risk to public health through their potential to cause severe illness in susceptible infants who consume contaminated powdered infant formula (PIF). Assessment of this risk is dependent on determining prevalence in PIF-producing factories, which can be challenging to measure with the heterogeneity observed in the design of built process facilities. There is also a potential risk of bacterial growth occurring during rehydration, given the observed persistence of Cronobacter in desiccated conditions. In addition, novel detection methods are emerging to effectively track and monitor Cronobacter species across the food chain. This review will explore the different vehicles that lead to Cronobacter species' environmental persistence in the food production environment, as well as their pathogenicity, detection methods and the regulatory framework surrounding PIF manufacturing that ensures a safe product for the global consumer.

CareerFIT Publication

https://doi.org/10.3390/microorganisms11061379

Comprehensive Genomic Characterization of Cronobacter sakazakii Isolates from Infant Formula Processing Facilities Using Whole-Genome Sequencing

Mousavi, Z.E., Koolman, L., Macori, G., Fanning, S., Butler, F.

Microorganisms, 2023

Cronobacter sakazakii is an opportunistic pathogen linked to outbreaks in powdered infant formula (PIF), primarily causing meningitis and necrotizing enterocolitis. Whole-genome sequencing (WGS) was used to characterize 18 C. sakazakii strains isolated from PIF (powdered infant formula) manufacturing plants (2011–2015). Sequence Type (ST) 1 was identified as the dominant sequence type, and all isolates carried virulence genes for chemotaxis, flagellar motion, and heat shock proteins. Multiple antibiotic resistance genes were detected, with all isolates exhibiting resistance to Cephalosporins and Tetracycline. A significant correlation existed between genotypic and phenotypic antibiotic resistance. The plasmid Col(pHAD28) was identified in the isolates recovered from the same PIF environment. All isolates harbored at least one intact phage. All the study isolates were compared with a collection of 96 publicly available C. sakazakii genomes to place these isolates within a global context. This comprehensive study, integrating phylogenetic, genomic, and epidemiological data, contributes to a deeper understanding of Cronobacter outbreaks. It provides valuable insights to enhance surveillance, prevention, and control strategies in food processing and public health contexts.

CareerFIT Publication

https://doi.org/10.3390/microorganisms11112749

A porous-crust drying model for a single dairy droplet

O'Connell K.; Olaleye A.K.; Van den Akker H.E.A.

Chemical Engineering Research and Design, 2023

The development of a novel numerical model for droplet drying is the topic of this paper. The three main stages of droplet drying are distinguished, viz. unhindered evaporation of a 'wet' particle (the droplet), restricted drying at a falling rate due to the formation of a crust around a wet core, and inert heating of the dry porous particle. Each stage is mathematically detailed to replicate all phenomena occurring throughout the drying process. The focus, however, is on the falling rate drying regime which is described in terms of Stefan diffusion of water vapour through the pores of a thickening crust. To this end, the model needs the material properties. This permits the droplet characteristics to be determined by composition rather than through single-droplet drying experiments. Finally, the model is validated against five of such experiments from literature using skim milk. Good agreement is found at each comparative case for the particle mass and temperature throughout the various drying regimes providing that for good reasons in three cases a lower drying air temperature is applied than reported for the experiments. The model is capable of predicting the entire drying process at low computational cost and without requiring empirical input.

https://doi.org/10.1016/j.cherd.2023.11.040

Yogurt fortified with various protein hydrolysates: Texture and functional properties

Abdel-Hamid M.; Hamed A.M.; Walker G.; Romeih E.

Food Chemistry, 2024

This work evaluated the impact of incorporating 1% of commercial protein hydrolysates [rice protein hydrolysate (RPH), pea protein hydrolysate (PPH), and casein hydrolysate (CH)] on the functional, microstructure, and texture properties of set yogurt. Yogurt prepared with RPH exhibited the highest viability number of Streptococcus thermophilus. The addition of three hydrolysate types to yogurt revealed significant increases in the antioxidant and ACE-inhibitory activities, where the highest values were noted for the yogurt prepared with RPH. RPH exhibited no differences in texture properties (firmness, consistency, and cohesiveness) to control yogurt. These results were confirmed by scanning electron microscope examination. RPH and control yogurts showed compacted and dense structures accompanied by small pores, whereas CH and PPH yogurt structures were characterized by coarse networks with large voids. Furthermore, there was no significant impact of adding protein hydrolysates on the overall acceptability of yogurt as indicated by a sensory panel.

CareerFIT Publication

https://doi.org/10.1016/j.foodchem.2024.140861

From lab-based to in-line: Analytical tools for the characterization of whey protein denaturation and aggregation–A review

Finnegan E.W.; Goulding D.A.; O'Callaghan T.F.; O'Mahony J.A.

Comprehensive Reviews in Food Science and Food Safety, 2024

Whey protein denaturation and aggregation have long been areas of research interest to the dairy industry, having significant implications for process performance and final product functionality and quality. As such, a significant number of analytical techniques have been developed or adapted to assess and characterize levels of whey protein denaturation and aggregation, to either maximize processing efficiency or create products with enhanced functionality (both technological and biological). This review aims to collate and critique these approaches based on their analytical principles and outline their application for the assessment of denaturation and aggregation. This review also provides insights into recent developments in process analytical technologies relating to whey protein denaturation and aggregation, whereby some of the analytical methods have been adapted to enable measurements in-line. Developments in this area will enable more live, in-process data to be generated, which will subsequently allow more adaptive processing, enabling improved product quality and processing efficiency. Along with the applicability of these techniques for the assessment of whey protein denaturation and aggregation, limitations are also presented to help assess the suitability of each analytical technique for specific areas of interest.

https://doi.org/10.1111/1541-4337.13289

Physicochemical properties of micellar casein retentates generated at different microfiltration temperatures

France T.C.; Bot F.; Kelly A.L.; Crowley S.V.; O'Mahony J.A.

Journal of Dairy Science, 2024

Processing temperature has a significant influence on the composition and functionality of the resulting streams following microfiltration (MF) of skim milk. In this study, MF and diafiltration (DF) were performed at 4 or 50°C to produce β-casein (β-CN)-depleted and nondepleted (i.e., native casein profile) micellar casein isolate retentates, respectively. Microfiltration combined with extensive DF resulted in a 40% depletion of β-CN at 4°C, whereas no β-CN depletion occurred at 50°C. Microfiltration at 4°C led to higher transmission of calcium into permeates, with retentate generated at 4°C containing less total calcium compared with retentate generated at 50°C, based on the volume of retentate remaining. Higher heat stability at 120°C was measured for retentates generated at 4°C compared with those at 50°C, across all pH values measured. Retentates generated at 4°C also had significantly lower ionic calcium values at each pH compared with those generated at 50°C. Higher apparent viscosities at 4°C were measured for retentates generated at 4°C compared with retentates generated at 50°C, likely due to increased voluminosity of β-CN-depleted casein micelles. The results of this study provide new information on how changing the composition of MF retentate, by appropriate control of processing temperature and DF, can alter physicochemical properties of casein micelles, with potential implications for ingredient functionality. © 2024 American Dairy Science Association

https://doi.org/10.3168/jds.2023-23918

Adaptive and predictive approaches to mitigate the impact of milk seasonality on composition, processing technologies and quality of milk powders

Hamed A.M.; Galli B.; Hogan S.A.; Abdel-Hamid M.; Romeih E.

International Journal of Dairy Technology, 2024

The diverse composition of milk throughout the year can potentially impact subsequent processing in the dairy industry and the quality of the final products. This fluctuation in milk composition is influenced by direct and indirect factors like seasonal variability. Milk powders are produced through a complex process and are intended for various end uses and require consistency of composition along with desirable physical and functional properties. This review aims to report technical challenges and limitations related to the functional and quality characteristics of milk powder and highlight recent approaches used to mitigate seasonally related differences in milk composition.

https://doi.org/10.1111/1471-0307.13148

Growth and fatty acid profile of Nannochloropsis oceanica cultivated on nano-filtered whey permeate

Kiani H.; Ma Q.; Xiao M.; Li Y.; Brooke F.J.; Mulcahy S.; Miros S.; Halim R.

Journal of Applied Phycology, 2024

Nano-filtered whey permeate (WP), a major by-product of dairy industry, is produced by membrane filtration of whey. The oleaginous microalga Nannochloropsis oceanica was successfully cultivated on WP without salinity and nutrient amendments. Growth, cell characteristics, and fatty acid profile of the cultures were analyzed using microscopy, flow cytometry, and GC analysis. WP was nitrogen limited, comprising primarily protein as a nitrogen source and only small amounts of free inorganic nitrogen (in the form of nitrate). Nannochloropsis oceanica (and associated bacteria) efficiently removed nitrate (100%), protein (87%), and phosphate (74%) from the whey permeate. Microscopic and flow cytometric analysis revealed diverse size distributions in whey permeate cultures, with significant cell aggregation attributed to low-salinity acclimatization and nitrogen limitation. Autofluorescence analysis revealed reduced photosynthetic activity in whey permeate-grown cells, possibly as a consequence of heightened mixotrophic activities on carbon source in the medium. Low nitrogen availability in whey permeate resulted in biomass with a fatty acid profile enriched in saturated fatty acids. Despite this, a considerable level of the omega-3 polyunsaturated fatty acid (in the form of eicosapentanoic acid or EPA) was detected at ca. 16% of total fatty acids. Whey permeate proved beneficial for the growth of N. oceanica and yielded high concentrations of eicosapentaenoic acid in the extracted lipids for potential applications in the feed/food industries.

CareerFIT Publication

https://doi.org/10.1007/s10811-024-03287-x

Examination of the impact of using lactose or permeate for protein standardisation of skimmed milk on viscosity characteristics during evaporation

Long T.; Finnegan E.W.; Girivasan A.; Tarapata J.; McCarthy N.A.; O'Mahony J.A.; O'Callaghan T.F.

International Journal of Dairy Technology, 2024

The effect of permeate and lactose for protein standardisation of skim milk concentrate, was investigated during evaporation. Analysis of the viscosity–total solids (TS) profiles of each treatment demonstrated that the unstandardised protein sample had the greatest increase in viscosity, followed by permeate and finally lactose-standardised samples. Heat stability and acid buffering capacity of the permeate standardised skim milk samples were higher when compared to the lactose-standardised samples. This work identifies how standardisation media can impact the viscosity of concentrated skim milk, enabling higher TS at the evaporator outlet in some circumstances which could have the potential to improve overall process efficiency. Furthermore this work demonstrates that, evaporating to a target viscosity rather than target TS would offer greater control and consistency during processing.

https://doi.org/10.1111/1471-0307.13138

Microfiltration retentate co-product from whey protein isolate production - Composition, processing, applications and potential for value addition

Mestawet A.T.; France T.C.; Mulcahy P.G.J.; O'Mahony J.A.

Trends in Food Science and Technology, 2024

Background: Microfiltration retentate (MFR), also called whey protein phospholipid concentrate, is a co-product of whey protein isolate (WPI) production derived through microfiltration (MF) of whey or whey protein concentrate. Microbiological quality and protein denaturation/aggregation in the MFR stream present challenges in valorizing the stream for utilization in specialized nutritional products. As a result, MFR is underutilized, with its current applications largely limited to commodity applications in the animal feed industry as a milk replacer and in confectionery, for example. On the other hand, the production of MFR is increasing year on year due to the increase in demand for WPI with its current production representing 14–18% of the total whey processed worldwide. Scope and approach: In this review, we discuss MFR processing options, composition, current applications, future perspectives, and potential valorization strategies and challenges. Our approach includes a comprehensive literature review of recent studies and advancements in MFR processing. We systematically selected and analyzed peer-reviewed articles, industry websites, and reports to provide a holistic view of the current state and future directions of MFR technology. Key findings and conclusions: The gross chemical composition of MFR is highly variable, with typical values of fat, protein, lactose, and ash ranging from 11 to 38%, 50–70%, 1–11%, and 2–4%, respectively. The protein constituents in MFR include β-lactoglobulin, α-lactalbumin, bovine serum albumin, lactoferrin, immunoglobulins, and caseino-macropeptide. Additionally, MFR is enriched with milk fat globule membrane-associated proteins such as butyrophilin, mucin 1, xanthine oxidase, and phospholipids like sphingomyelin and phosphatidylcholine. Significant research gaps exist in understanding the microbiology, bioactivity, and bioavailability of MFR components, which are crucial for supporting its valorization. Despite these gaps, there is great potential for utilizing MFR in the food industry, neonatal nutrition, and pharmaceutical applications. This potential provides opportunities to develop targeted, novel value-added ingredients from the MFR stream. © 2024 The Authors

CareerFIT Publication

https://doi.org/10.1016/j.tifs.2024.104739

Component partitioning during microfiltration and diafiltration of whey protein concentrate in the production of whey protein isolate

Mestawet A.T.; France T.C.; Mulcahy P.G.J.; O'Mahony J.A.

International Dairy Journal, 2024

This study investigated component partitioning during cold microfiltration (MF) and diafiltration (DF) of whey protein concentrate (WPC) feed in producing whey protein isolate (WPI). Significant differences ($P < 0.05$) were found in the partitioning of components. Specifically, 60.1, 50.2, 6.32, and 75.7% of total solids, protein, fat, and ash, respectively, were partitioned into the permeate stream. Phospholipids comprised 25 and 41.4% of total fat in WPC feed and DF retentate, respectively. Sodium dodecyl sulphate-polyacrylamide gel electrophoresis showed MFGM-associated proteins were enriched in the MF retentate. The particle size in MF retentate was significantly larger ($P < 0.05$) than in the MF and DF permeate streams (450, 7.87, and 3.55 nm, respectively), providing evidence of the retention of aggregated whey proteins in the MF retentate. These findings provide an indepth understanding of component partitioning during cold MF of WPC feed, supporting the development of higher value-added ingredients. © 2024

CareerFIT Publication

https://doi.org/10.1016/j.idairyj.2024.106006

Prediction of milk composition using multivariate chemometric modelling of infrared, Raman, and fluorescence spectroscopic data: A review

Mohammadi S.; Gowen A.; Luo J.; O'Donnell C.

Food Control, 2024

Quality assessment of milk which is a comprehensive source of nutrients for humans and an important raw material for other dairy products is required in the dairy industry. Rapid, cost-effective, and non-destructive spectroscopic techniques are more preferable than classic wet chemistry approaches for milk analysis. The objective of this work was to review the prediction of milk composition including macronutrients such as fat, protein and lactose and micronutrients such as fatty acids and vitamins using multivariate chemometric modelling of Near Infrared (NIR), Mid Infrared (MIR), fluorescence, and Raman spectral data and data fusion approaches. Literature sources describing spectroscopic analysis of milk samples and the application of multivariate data analysis methods are outlined in this literature review. In addition, the importance of data fusion strategies employed for combing different spectroscopic techniques are reviewed to evaluate their potential to improve the accuracy of the prediction models developed. Recent research studies have demonstrated that the use of data fusion strategies improves the performance of milk composition prediction models developed. © 2024 The Authors

https://doi.org/10.1016/j.foodcont.2024.110658

Vibrational spectroscopy data fusion for enhanced classification of different milk types

Mohammadi S.; Gowen A.; O'Donnell C.

Heliyon, 2024

The aim of this study is to classify seven types of Irish milk (butter, fresh, heart active, lactose free, light, protein, and slimline), supplied by a specific company, using vibrational spectroscopy methods: Near infrared (NIR), mid infrared (MIR), and Raman spectroscopy. In this regard, chemometric methods were used, and the impact of spectral data fusion on prediction accuracy was evaluated. A total of 105 samples were tested, with 21 used in the test set. The study assessed principal component analysis (PCA), partial least square discriminant analysis (PLS-DA), and sequential and orthogonalized partial least squares linear discriminant analysis (SO-PLS-LDA) for classifying different milk types. The prediction accuracy, when applying PLS-DA on individual blocks of data and low-level fused data, did not exceed 85.71 %. However, implementing the SO-PLS-LDA strategy significantly improved the accuracy to 95 %, suggesting a promising method for the development of classification models for milk using data fusion strategies.

https://doi.org/10.1016/j.heliyon.2024.e36385

The Impact of pH on Fouling and Related Physicochemical Properties of Skim Milk Concentrate during Heat Treatment Using a Laboratory-Scale Fouling Rig

Murphy T.R.; Finnegan E.W.; Tarapata J.; O'Callaghan T.F.; O'Mahony J.A.

Foods, 2024

The objective of this study was to investigate the effect of pH (6.1, 6.3, 6.5, and 6.7) on heat-induced changes in concentrated skim milk as related to fouling in heat exchangers. Skim milk (30%, w/w, total solids) was recirculated in a laboratory-scale fouling rig at an initial target temperature of 85 °C for 90 min to simulate thermal processing and preheating of evaporated liquid concentrate feeds in dairy processing. This study investigated key changes in relevant physicochemical properties, such as viscosity, particle size, and sedimentation, as major contributors to fouling at lower pHs (6.1 and 6.3). Additionally, protein aggregation and calcium phosphate precipitation were identified as significant contributors to fouling deposits. Possible strategies to mitigate fouling were determined, including optimizing pH and adjusting heat treatment parameters to minimize protein denaturation and mineral deposition. The findings indicate that carefully controlling pH and processing parameters can greatly enhance the efficiency of milk concentration by evaporation and tailor finished product quality. Moreover, this study showed that monitoring of CIP solutions for protein content and turbidity provides valuable information on the intensity of fouling and the efficiency of cleaning.

https://doi.org/10.3390/foods13193100

A Review on MIR, NIR, Fluorescence and Raman Spectroscopy Combined with Chemometric Modeling to Predict the Functional Properties of Raw Bovine Milk

Ní Fhuaráin A.M.; O'Donnell C.P.; Luo J.; Gowen A.A.

ACS Food Science and Technology, 2024

Spectroscopic methods, such as Mid-Infrared (MIR), Near-Infrared (NIR), fluorescence and Raman spectroscopy are rapid, inexpensive and nondestructive. Traditionally, mainly MIR and NIR spectroscopy have been employed to predict the compositional properties of milk. However, measurement of the key functional properties of milk is of high industry relevance. In this review, studies on the use of spectroscopic techniques for predicting milk functional properties are compared and reported models are outlined. The challenges of employing spectroscopy in functionality applications are discussed. For pH and curd yield, some of the MIR models display a robust prediction performance. With further model validation, calibrations for these properties could potentially be added to existing MIR instruments in the industry. Despite fluorescence and NIR spectroscopy being used for many dairy applications, their use for milk functionality is limited currently. As Raman spectroscopy is sensitive to the components of raw milk, it has potential for predicting milk functional properties.

https://doi.org/10.1021/acsfoodscitech.4c00130

Alteration of Physicochemical Properties and Heating Stability of Reconstituted Acid Whey Powder by Calcium Chelating Salts

Purwanti N.; Mulcahy S.; Murphy E.G.

Food and Bioprocess Technology, 2024

Trisodium citrate (TSC) and ethylenediaminetetraacetic acid disodium salt (Na2-EDTA) were applied in reconstituted acid whey powder (AWP) at 20% w/w, which mimicked acid whey concentration during industrial whey processing. Physicochemical properties and heat stability of the AWP suspensions with 0–50 mM TSC and Na2-EDTA at pH 6.2 were investigated. TSC-containing suspensions prior to heating had decreasing Ca2+ activity, levels of sedimentation, and subtle reduction of aggregate size with increasing TSC concentrations (0–50 mM). Unheated Na2-EDTA-containing suspensions had lower levels of sedimentation and smaller aggregate sizes than unheated TSC-containing suspensions; however, reduction of Ca2+ activity was only observed up to 20 mM Na2-EDTA. Stronger effects of Na2-EDTA than TSC on levels of sediment, viscosity, and aggregate size of AWP suspensions were observed after heating, except for 50 mM Na2-EDTA. A remarkable difference between TSC and Na2-EDTA addition was the nature of aggregates formed in heated suspensions. TSC-containing suspensions contained larger aggregates than corresponding Na2-EDTA-containing suspensions, which exhibited increasing shear thinning behavior as a function of concentration. In contrast, the smaller aggregates in the corresponding Na2-EDTA-containing suspension showed shear thickening. The inverse relationship between aggregate size and levels of sediment for TSC-containing suspensions post-heat treatment may indicate the formation of loose aggregates that resist sedimentation.

CareerFIT Publication

https://doi.org/10.1007/s11947-023-03198-8

Efficient mass-preserving finite volume approach for the rennet-induced coagulation equation

Singh M.; Sriwastav N.; Shardt O.

Chaos, Solitons and Fractals, 2024

The coagulation of casein micelles caused by enzymes is a critical step in the dairy industry for cheese manufacture. During enzymatic coagulation of milk, three processes occur: enzymic proteolysis, coagulation, and gelation. This study presents the first numerical approach based on a finite volume scheme for describing the enzyme-induced coagulation of casein micelles. The finite volume scheme is mainly concerned with ensuring mass conservation and developed on the assumption that the particles are concentrated on the mean of each cell of the discretization. The key advantages of the new technique are its simple mathematical formulation and its robustness that allow it to be implemented on any type of grid and tailored to different coagulation kernels. The accuracy of the new approach is compared with newly derived analytical results for several gelling and non-gelling coagulation kernels. The comparison demonstrates that the new approach closely matches the exact results. In order to analyse the convergence behaviour of different order moments, various refined non-uniform grids have been taken into consideration.

https://doi.org/10.1016/j.chaos.2024.114692

Physicochemical properties and stability of milk permeate as influenced by ultrafiltration processing parameters

Tsermoula P.; Barone G.; O'Mahony J.A.

International Dairy Journal, 2024

The objective of this study was to determine the effect of membrane molecular weight cut-off (5 and 10 kDa), and filtration temperature (25, 15 and 10 °C) on the physicochemical properties of milk permeate (MP). Although MPs produced had a similar gross chemical composition, MP produced with the 10 kDa membrane at 25 °C had the lowest pH (6.64) and ionic calcium content (2.33 mM), while MP produced with the 5 kDa membrane at 10 °C had the highest levels of 6.82 and 2.85 mM for pH and ionic calcium, respectively. Incubation of MPs at 60 °C resulted in precipitation, with MPs produced with the 10 kDa membrane having larger, less soluble and thermodynamically more stable particles than MPs produced with the 5 kDa membrane. These results demonstrate that filtration parameters significantly affected the physicochemical properties of MPs, with implications for downstream processing.

https://doi.org/10.1016/j.idairyj.2024.106005

Seasonal and geographical impact on the Irish raw milk microbiota correlates with chemical composition and climatic variables

Yap M.; O'Sullivan O.; O'Toole P.W.; Sheehan J.J.; Fenelon M.A.; Cotter P.D.

mSystems, 2024

Season and location have previously been shown to be associated with differences in the microbiota of raw milk, especially in milk from pasture-based systems. Here, we further advance research in this area by examining differences in the raw milk microbiota from several locations across Ireland over 12 months, and by investigating microbiota associations with climatic variables and chemical composition. Shotgun metagenomic sequencing was used to investigate the microbiota of raw milk collected from nine locations (n = 241). Concurrent chemical analysis of the protein, fat, lactose, total solids, nonprotein nitrogen contents, and titratable acidity (TA) of the same raw milk were performed. Although the raw milk microbiota was highly diverse, a core microbiota was found, with Pseudomonas_E, Lactococcus, Acinetobacter, and Leuconostoc present in all samples. Microbiota diversity significantly differed by season and location, with differences in seasonality and geography corresponding to 11.8% and 10.5% of the variation in the microbiota. Functional and antibiotic resistance profiles also varied across season and location. The analysis of other metadata revealed additional interactions, such as an association between mean daily air and grass temperatures with the abundance of spoilage taxa like Pseudomonas species. Correlations were identified between pathogenic, mastitis-related species, fat content, and the number of sun hours, suggesting a seasonal effect. Ultimately, this study expands our understanding of the interconnected nature of the microbiota, environment/climate variables, and chemical composition of raw milk and provides evidence of a season- and location-specific microbiota. IMPORTANCE The microbiota of raw milk is influenced by many factors that encourage or prevent the introduction and growth of both beneficial and undesirable microorganisms. The seasonal and geographical impacts on the microbial communities of raw milk have been previously seen, but the relationships with environmental factors and the chemical composition has yet to be investigated. In this year-long study, we found that while raw milk is highly diverse, a core microbiota was detected for Irish raw milk, with strong evidence of seasonal and geographical influence. We also found associations between groups of microorganisms, environmental factors, and milk composition, which expand current knowledge on the relationships between microbial and chemical composition and the climate. These results provide evidence for the development of a tool to allow for the prediction of raw milk quality and safety.

https://doi.org/10.1128/msystems.01290-23

Research Programme: *Phase 2, RFA2*

Potential loss of nutrients, carbon and metals in simulated runoff associated with dairy processing sludge application

Ashekuzzaman S.M.; Forrestal P.; Richards K.; Fenton O.

International Journal of Environmental Science and Technology, 2020

Dairy processing wastewater treatment sludge (DPWTS) is applied to grassland to recycle valuable nutrients and organic matter. Until recently the chemical composition of the dominant DPWTS types (calcium, aluminium or iron rich) was unknown, but the latest study (Ashekuzzaman et al. in J Clean Prod 230:1266–1275, 2019) indicates that DPWTS has high nitrogen (N) and phosphorus (P) content and their inherent chemical properties may influence their availability and losses. Herein for the first time edge of field-losses and plant-available P changes are simulated in an agitator test 48 h after application. In terms of overall losses, metals are not of concern across treatment types, iron-rich DPWTS has the highest losses in terms of concentration of ammonium-N and carbon, whereas calcium-rich DPWTS has the highest dissolved reactive P (DRP) losses but lowest losses of ammonium-N and carbon. The loss of DRP was found to be strongly positively associated with the increase in water-extractable P, degree of P saturation, Morgan's and Mehlich-3 extractable phosphorus (Pm, M3-P), respectively. Runoff concentrations presented here represent edge of field-losses and may not represent final concentrations entering a surface waterbody. In terms of plant-available P, there were no negative effects with Pm exhibiting a positive trend across DPWTS types and soils. In particular, a significant increase was found for the calcium-rich DPWTS across all soils (average increase in Pm by fivefold). As applying DPWTS to grassland is an understudied area, further field trials should focus on emissions to air and water and examine the fertilizer value from N and P perspectives. Thus a better management of DPWTS as fertiliser can be maintained from an agronomic and environmental context.

https://doi.org/10.1007/s13762-020-02768-z

Novel Use of Dairy Processing Sludge Derived Pyrogenic Char (DPS-PC) to Remove Phosphorus in Discharge Effluents

Ashekuzzaman S.M.; Kwapinska M.; Leahy J.J.; Richards K.; Fenton O.

Waste and Biomass Valorization, 2020

Purpose: Pyrogenic char (PC) materials derived from the pyrolysis of dairy processing sludge (DPS) could be a cost effective option to develop carbonaceous adsorbent for phosphorus (P) removal from wastewater. The main objectives of the present work were to: (1) determine the efficacy of DPS derived PC (DPS-PC) to remove P from synthetic and dairy wastewater samples, (2) identify possible P removal mechanisms, and identify parameters that could be used to quickly identify the P removal capacity of a char and (3) propose a ranking system for the selection of DPS-PC which includes energy, char yield and P removal criterion. Methods: DPS-PC samples were obtained from the pyrolysis process (700 °C) of two sludge streams: (1) bio-chemically treated mixed sludge and (2) lime treated dissolved air floatation (DAF) sludge. Herein, 12 DPS-PC samples were assessed and pre-screened in batch experiments to determine the P removal efficacy from both synthetic and dairy wastewater solutions. The effect of solid to liquid dosage, contact time, pH and P concentration was investigated. Statistical regression and correlation analyses were performed to understand P removal mechanism. The quantitative assessment of char yield, energy balance and P removal performance were combined to propose a ranking system for DPS feedstock selection. Results: P removal varied across DPS-PC type and composition, with mixed sludge derived char exhibiting 85–98% P removal at a dose of between 10 and 50 g/L, whereas, those from DAF sludge removed > 99% at 3 g/L. The P removal process was associated with a number of strongly significant mineral phase correlations pertaining to mineral composition (i.e. availability of Ca, Mg and Si) of the DPS-PC samples. A quick water extractible P test together with knowledge of the major P locking minerals can be used to pre-screen the potential of PC for P removal application. This study also provides a physicochemical reference and ranking of DPS feedstock selection, which will be useful for future investigation on the pyrolysis of DPS at pilot-scale and subsequently, to develop PC based efficient adsorbent for application in wastewater treatment. Graphic Abstract: [Figure not available: see fulltext.]. © 2019, Springer Nature B.V.

http://dx.doi.org/10.1007/s12649-019-00731-9

Highly selective trace ammonium removal from dairy wastewater streams by aluminosilicate materials

O'Connor E.; Kavanagh O.N.; Chovan D.; Madden D.G.; Cronin P.; Albadarin A.B.; Walker G.M.; Ryan A.

Journal of Industrial and Engineering Chemistry, 2020

Water is a key solvent, fundamental to supporting life on earth. It is equally important in many industrial processes, particularly within agricultural and pharmaceutical industries, which are major drivers of the global economy. The results of water contamination by common activity in these industries is well known and EU Water Quality Directives and Associated Regulations mandate that NH4 + concentrations in effluent streams should not exceed 0.3 mg L−1, this has put immense pressure on organisations and individuals operating in these industries. As the environmental and financial costs associated with water purification begin to mount, there is a great need for novel processes and materials (particularly renewable) to transform the industry. Current solutions have evolved from combating toxic sludge to the use of membrane technology, but it is well known that the production of these membrane technologies creates a large environmental footprint. Zeolites could provide an answer; their pore size and chemistry enable efficient removal of aqueous based cations via simple ion exchange processes. Herein, we demonstrate efficient removal of NH4 + via both static and dynamic methodology for industrial application. Molecular modelling was used to determine the cation–framework interactions which will enable customisation and design of superior sorbents for NH4 + capture in wastewater.

https://doi.org/10.1016/j.jiec.2019.10.027

Microbial Community Redundancy and Resilience Underpins High-Rate Anaerobic Treatment of Dairy-Processing Wastewater at Ambient Temperatures

Paulo L.M.; Castilla-Archilla J.; Ramiro-Garcia J.; Escamez-Picón J.A.; Hughes D.; Mahony T.; Murray M.; Wilmes P.; O'Flaherty V.

Frontiers in Bioengineering and Biotechnology, 2020

High-rate anaerobic digestion (AD) is a reliable, efficient process to treat wastewaters and is often operated at temperatures exceeding 30°C, involving energy consumption of biogas in temperate regions, where wastewaters are often discharged at variable temperatures generally below 20°C. High-rate ambient temperature AD, without temperature control, is an economically attractive alternative that has been proven to be feasible at laboratory-scale. In this study, an ambient temperature pilot scale anaerobic reactor (2 m3) was employed to treat real dairy wastewater in situ at a milk processing plant, at organic loading rates of 1.3 ± 0.6 to 10.6 ± 3.7 kg COD/m3/day and hydraulic retention times (HRT) ranging from 36 to 6 h. Consistent high levels of COD removal efficiencies, ranging from 50 to 70% for total COD removal and 70 to 84% for soluble COD removal, were achieved during the trial. Within the reactor biomass, stable active archaeal populations were observed, consisting mainly of Methanothrix (previously Methanosaeta) species, which represented up to 47% of the relative abundant active species in the reactor. The decrease in HRT, combined with increases in the loading rate had a clear effect on shaping the structure and composition of the bacterial fraction of the microbial community, however, without affecting reactor performance. On the other hand, perturbances in influent pH had a strong impact, especially when pH went higher than 8.5, inducing shifts in the microbial community composition and, in some cases, affecting negatively the performance of the reactor in terms of COD removal and biogas methane content. For example, the main pH shock led to a drop in the methane content to 15%, COD removals decreased to 0%, while the archaeal population decreased to ~11% both at DNA and cDNA levels. Functional redundancy in the microbial community underpinned stable reactor performance and rapid reactor recovery after perturbations.

https://doi.org/10.3389/fbioe.2020.00192

Enhanced Methanization of Long-Chain Fatty Acid Wastewater at 20°C in the Novel Dynamic Sludge Chamber–Fixed Film Bioreactor

Singh S.; Holohan B.C.; Mills S.; Castilla-Archilla J.; Kokko M.; Rintala J.; Lens P.N.L.; Collins G.; O'Flaherty V.

Frontiers in Energy Research, 2020

Lipid-containing wastewaters, such as those arising from dairy processing, are frequently discharged at temperatures ≤ 20°C. Their valorization at low ambient temperatures offers opportunities to expand the application of high-rate anaerobic wastewater treatment toward achieving energy neutrality by minimizing the energy demand for heating. Lipid hydrolysis generates long-chain fatty acids (LCFAs), which incur operational challenges and hinder stable bioreactor operation by inducing sludge flotation and washout, coupled with the added challenge of treatment at lower temperature (20°C). These challenges are tackled together uniquely during the treatment of LCFA-rich synthetic dairy wastewater (SDW) (33% COD-LCFA) through de novo formed microbial granular sludge within the dynamic sludge chamber–fixed film (DSC-FF) reactor. The novel reactor design facilitated sludge retention for the entire operational period of 150 days by containing settled, flotating, and LCFA-encapsulated granular sludge and biofilm within a single module. High COD removal efficiencies (87–98%) were achieved in the three replicated DSC-FF reactors, along with complete LCFA removal at 18–72 h HRT (LCFA loading rate of 220–890 mgCOD-LCFA/L·day) and partial LCFA removal at 12 h HRT (LCFA loading rate of 1333 mgCOD-LCFA/L·day). The high removal efficiencies of unsaturated and saturated LCFAs achieved are reported for the first time during continuous anaerobic wastewater treatment at low temperatures (20°C). Moreover, de novo granulation was achieved within 8 days from a combination of inoculum mixtures at a high LCFA concentration (33% COD-LCFA) in SDW. The results demonstrate the feasibility of the DSC-FF reactor for treating LCFA-rich wastewaters at discharge temperatures and offer potential for expanded and more energetically productive anaerobic valorization of lipid-rich wastewater.

https://doi.org/10.3389/fenrg.2020.00166

Grassland Phosphorus and Nitrogen Fertiliser Replacement value of Dairy Processing Dewatered Sludge

Ashekuzzaman S.M.; Forrestal P.; Richards K.G.; Daly K.; Fenton O.

Sustainable Production and Consumption, 2021

Dairy processing sludge is currently a bio-based fertiliser being spread to grassland without knowledge pertaining to its phosphorus (P) or nitrogen (N) fertiliser replacement value. This creates uncertainty of desired crop yield achievement and unproductive nutrient recycling and also poses a great challenge to the dairy milk processing industry in promoting their food processing by-product as valuable recyclable fertiliser. Therefore four representative samples, i.e. two activated sludge (aluminium-precipitated (Al-sludge) and iron-precipitated (Fe-sludge)), and two lime-stabilised calcium-precipitated sludge (Ca1- and Ca2-sludge), were examined at field scale to assess P and N availability for crop yield and uptake in comparison to reference mineral fertilisers over one seasonal year. The field plots were set-up on a light textured clay loam soil within the optimum plant available P (Morgan's soil P index 3, i.e. medium / adequate soil P level) in two separate adjoining areas consisting of P and N availability experiments. Each experiment consisted of 40 plots (each 8×2 m2) of 10 treatments with 4 replications arranged in a randomised complete block design. All dairy sludge (40 kg-P ha−1) and mineral P treatments (rates 0–50 kg-P ha−1) produced similar yields and uptake, and crop P was not affected by sludge applications despite the presence of high Al, Ca and Fe. During the experiment there was no significant change in P index (stayed at index 3) indicating that no treatment caused a decline in P into index 2 (i.e. low soil P level), therefore replacing P removed by the crop. The only change in Morgan's P was observed in the Ca-sludge treatments, but this was due to Morgan's reagent overestimating plant available P in high Ca conditions. From N trial plots a significantly higher grass yield and N uptake was observed for Fe and both Ca-type sludge applied plots than the control (zero N) plot during the 1st harvest, while no statistical difference observed in the subsequent harvests (up to 4th harvesting). The N fertiliser replacement value (derived from mineral N response) of sludge samples was observed to be in the order of Fe (54%)>Ca2 (25%)>Ca1 (22%)>Al (8%) with greater promise of N fertiliser efficiency of Fe and Ca types. Overall these bio-based sludges show promise in recycling P and N for grassland application but longer term trials in other soil types considering other environmental aspects (losses to soil, water and air) can further optimize the management of dairy sludge as an alternative to chemical fertiliser. © 2020

http://dx.doi.org/10.1016/j.spc.2020.11.017

Systematic Review of Dairy Processing Sludge and Secondary STRUBIAS Products Used in Agriculture

Hu Y.; Khomenko O.; Shi W.; Velasco-Sánchez Á.; Ashekuzzaman S.M.; Bennegadi-Laurent N.; Daly K.; Fenton O.; Healy M.G.; Leahy J.J.; Sørensen P.; Sommer S.G.; Taghizadeh-Toosi A.; Trinsoutrot-Gattin I.

Frontiers in Sustainable Food Systems, 2021

Worldwide dairy processing plants produce high volumes of dairy processing sludge (DPS), which can be converted into secondary derivatives such as struvite, biochar and ash (collectively termed STRUBIAS). All of these products have high fertilizer equivalent values (FEV), but future certification as phosphorus (P)-fertilizers in the European Union will mean they need to adhere to new technical regulations for fertilizing materials i.e., content limits pertaining to heavy metals (Cd, Cu, Hg, Ni, Pb, and Zn), synthetic organic compounds and pathogens. This systematic review presents the current state of knowledge about these bio-based fertilizers and identifies knowledge gaps. In addition, a review and calculation of greenhouse gas emissions from a range of concept dairy sludge management and production systems for STRUBIAS products [i.e., biochar from pyrolysis and hydrochar from hydrothermal carbonization (HTC)] is presented. Results from the initial review showed that DPS composition depends on product type and treatment processes at a given processing plant, which leads to varied nutrient, heavy metal and carbon contents. These products are all typically high in nutrients and carbon, but low in heavy metals. Further work needs to concentrate on examining their pathogenic microorganism and emerging contaminant contents, in addition to conducting an economic assessment of production and end-user costs related to chemical fertilizer equivalents. With respect to STRUBIAS products, contaminants not present in the raw DPS may need further treatment before being land applied in agriculture e.g., heated producing ashes, hydrochar, or biochar. An examination of these products from an environmental perspective shows that their water quality footprint could be minimized using application rates based on P incorporation of these products into nutrient management planning and application by incorporation into the soil. Results from the concept system showed that elimination of methane emissions was possible, along with a reduction in nitrous oxide. Less carbon (C) is transferred to agricultural fields where DPS is processed into biochar and hydrochar, but due to high recalcitrance, the C in this form is retained much longer in the soil, and therefore STRUBIAS products represent a more stable and long-term option to increase soil C stocks and sequestration.

REFLOW project

https://doi.org/10.3389/fsufs.2021.763020

Sewage Sludge Thermal Treatment Technologies with a Focus on Phosphorus Recovery: A Review

Kwapinski W.; Kolinovic I.; Leahy J.J.

Waste and Biomass Valorization, 2021

Phosphorus presents a limited, irreplaceable and essential nutrient necessary for the growth of organisms. There is an increasing effort to recover phosphorus from production waste streams. Sewage sludge presents an important source of phosphorus but also contains organic pollutants and heavy metals. Thermal treatment technologies seem to be a promising option to treat sewage sludge and obtain ash/char from which high recovery rate of phosphorus can be reached. In this review, sewage sludge management options in compliance with EU legal requirements are first reviewed. Follows, an overview of sewage sludge thermal treatment technologies including incineration, hydrothermal carbonisation, pyrolysis and gasification, for the purpose of phosphorus recapture. We summarize recent advances in thermal treatment processes of sewage sludge and phosphorus recovery, identify challenges and knowledge gaps. Thermochemical methods proved to have many advantages over pure wet chemical methods for phosphorus recovery. The review provides the foundation for future research aimed at achieving efficient, economic and environmental sustainable recapture of phosphorus from sludge thermal treatment products. Graphic Abstract: [Figure not available: see fulltext.]. © 2021, Springer Nature B.V.

REFLOW project

https://doi.org/10.1007/s12649-020-01280-2

Milk reception in a time-efficient manner: A case from the dairy processing plant

Zacharski K.A.; Burke N.; Adley C.C.; Hogan P.; Ryan A.; Southern M.

Food Control, 2021

The short raw milk lifespan is a matter of concern for the dairy processing sector. It is crucial to the final product quality to ensure that raw milk will reach the cooling facility without undue delay while maintaining high hygienic standards. However, an effective milk reception is undermined by numerous internal and external challenges due to the complexity of the dairy manufacturing system and the stochastic variation of the milk supply chain. This work presents an industrial case study where the milk reception performance was examined, and opportunities for improvement were identified. The output provided operational documentation of each stage of milk reception. The outcomes illustrate that existing infrastructure and operations were not set up to manage a post-quota abolition uptake in milk production. A number of shortcomings and challenges were outlined, namely process bottlenecks, inefficient design of the facility layout, lack of standardized procedures, and internal-communication issues. Recommendations for improvements have been provided to achieve a 23.4% reduction of process lead time. These findings provide an opportunity for the industry to review their milk reception operations to deal with stochastic variations in milk supply and seasonality. © 2021 The Authors

https://dx.doi.org/10.1016/j.foodcont.2021.107939

Preliminary Assessment of Pyrolysis Biochar Derived from Milk/Dairy Processing Sludge as a Potential Component of Fertilizers

Kwapinska, M., Pisano, I., Leahy, J.J.

ACS Sustainable Chemistry and Engineering, 2022

Disposal of waste-activated sludge [dairy processing sludge, (DPS)] from wastewater treatment plants located in milk processing companies is an increasing concern. DPS is usually applied to farmlands in the vicinity of the dairy companies. This practice is becoming unsustainable due to uncontrolled nutrient loss and potential soil contamination. We propose to recover nutrients in the form of biochar. This paper examines the properties of biochars obtained from slow pyrolysis of DPS. DPS samples were pyrolyzed at laboratory and pilot scale at 600 and 700 °C. The elemental properties of biochars, the content of primary and secondary nutrients, as well as contaminants were examined and compared against the European Union Fertilizing Products Regulation. The biochars meet the specified limits for hydrogen-to-organic carbon ratio, chloride, and polycyclic aromatic hydrocarbons intended for gasification and pyrolysis component category materials. In six out of eight biochars, the content of phosphorus (P) as a single declared nutrient and the level of contaminants meet those required for an organo-mineral fertilizer. Only two biochars meet the required concentrations of nitrogen, phosphorus, and potassium. A minimum solid content of 30% in DPS is required to make the process of biochar production energetically sustainable.

https://doi.org/10.1021/acssuschemeng.2c06093

Polyhydroxyalkanoate bio-production and its rise as biomaterial of the future

Palmeiro-Sánchez, T.; O'Flaherty, V.; Lens, P.N.L.

Journal of Biotechnology, 2022

The first observation of a polyhydroxyalkanoate (PHA) aggregate was in 1888 by Beijenrinck. Despite polyhydroxybutyrate (PHB) being the first type of PHA discovered, it was not extracted and characterized until 1925 by Maurice Lemoigne in France, even before the concept of "macromolecules" was known. After more than 30 years, in 1958, Wilkinson and co-workers rediscovered PHB and its metabolic role in the cells as storage compound. PHB started to be appealing to the industry in the 1980s, when a few companies started to commercialize microbially produced PHAs. During the 1990 s, the focus was on reducing production costs to make PHA production economically feasible, for instance by genetically modified microorganisms and even plants. Since then, many advances have been made: diverse wastes as feedstock, different production processes, and tailored design of biopolymers. This paper summarizes the scientific and technological development of PHAs from their discovery in 1888 until their latest applications and current commercial uses. Future perspectives have been devised too based on the current bottlenecks.

CareerFIT Publication

https://doi.org/10.1016/j.jbiotec.2022.03.001

Fabrication and Evaluation of Filtration Membranes from Industrial Polymer Waste

Bano S.; Pednekar M.; Rameshkumar S.; Borah D.; Morris M.A.; Padamati R.B.; Cronly N.

Membranes, 2023

Polyvinylidene fluoride (PVDF) polymers are known for their diverse range of industrial applications and are considered important raw materials for membrane manufacturing. In view of circularity and resource efficiency, the present work mainly deals with the reusability of waste polymer 'gels' produced during the manufacturing of PVDF membranes. Herein, solidified PVDF gels were first prepared from polymer solutions as model waste gels, which were then subsequently used to prepare membranes via the phase inversion process. The structural analysis of fabricated membranes confirmed the retention of molecular integrity even after reprocessing, whereas the morphological analysis showed a symmetric bi-continuous porous structure. The filtration performance of membranes fabricated from waste gels was studied in a crossflow assembly. The results demonstrate the feasibility of gel-derived membranes as potential microfiltration membranes exhibiting a pure water flux of 478 LMH with a mean pore size of ~0.2 µm. To further evaluate industrial applicability, the performance of the membranes was tested in the clarification of industrial wastewater, and the membranes showed good recyclability with about 52% flux recovery. The performance of gel-derived membranes thus demonstrates the recycling of waste polymer gels for improving the sustainability of membrane fabrication processes.

https://doi.org/10.3390/membranes13040445

Optimising the quality management system in dairy processing

Burke, N.

Book: Quality control and Quality Assurance- Techniques and Applications, 2023

Milk has a solid reputation as a staple food since time immemorial. It is a complete food in its raw form, high in fat, protein, vitamins and minerals, including calcium. While the most beneficial first food for mammals is mammalian milk until weaning, cow's milk and dairy derivatives are considered significant nutritional components in the human diet. While milk consumption has in fact sharply declined in recent decades, the consumption of liquid milk derivatives and dairy products has steadily increased. Quality in terms of product, process and the environment in a milk production plant can be measured through performance, reliability and durability. The quality management system, in whatever form that may take within a plant, is the pinnacle in ensuring how one organisation can differentiate from its competitors. Quality systems and analytical testing protocols, especially in the dairy industry, are seldom quantified or fine-tuned to guarantee their efficiency. Furthermore, the impacts of quality systems on process, product, and environmental optimisation are frequently overlooked. This chapter reviews the activities that allow for the optimisation of quality systems in a dairy processing environment. The outcomes of which highlight the importance of process based quality systems.

https://doi.org/10.5772/intechopen.114055

Enhancement of biomethane potential of brown sludge by pre-treatment using vortex based hydrodynamic cavitation

Islam M.S.; Ranade V.V.

Heliyon, 2023

Novel, non-thermal and economically benign pre-treatment process was developed for enhancing valorisation potential of brown sludge generated by dairy industry wastewater treatment plant (WWTP). Vortex-based hydrodynamic cavitation (HC) device was used to quantify influence of pretreatment by measuring biomethane potential (BMP) of untreated and treated brown sludge. Pre-treatment parameters, primarily, pressure drop and number of passes through the cavitation device were varied to quantify influence on BMP. BMP tests were performed at 39 °C containing 5% of total solids in each reactors using an automatic BMP measurement system containing 15 reactors with each volume of 500 mL fitted with overhead stirrer. HC treatment increased the soluble chemical oxygen demand (sCOD) by more than 25% which increased the BMP. HC treatment was able to push the BMP of treated sludge to more than 80% of the theoretical BMP. Volatile solids (VS) removal was more than 65%. Highest methane yield was 376 mL/g-VS of sludge. The methodology and results presented here show significant potential to valorise brown dairy sludge via vortex based hydrodynamic cavitation.

https://doi.org/10.1016/j.heliyon.2023.e18345

A comparative study of thermally and chemically treated dairy waste: Impacts on soil phosphorus turnover and availability using 33P isotope dilution

Khomenko O.; Fenton O.; Leahy J.J.; Daly K.

Journal of Environmental Management, 2023

Dairy processing sludge (DPS) and DPS-derived secondary products such as struvite, biochar, hydrochar and ash (collectively known as SRUBIAS) are emerging as alternatives to fertilizers produced from mined rock phosphate. However, little is known about how these products affect soil P availability and daily P turnover rates. A lack of such information prevents precision nutrient management planning using these products out on farms. This study used a novel isotope dilution technique (IPD) with 33P as a tracer to compare P turnover in soils amended with chemically (alum-treated DPS and struvite) and thermally (biochar, hydrochar, ash) treated DPS. Results showed that thermally treated products exhibited poor agronomic performance as P fertilizers, potentially inhibiting P availability when applied to soils. For example, a P deficient soil amended with hydrochar treatment at the highest application rates did not record a build-up of available P to agronomic target values. In ash and biochar treated P deficient soils, available P increased but only with very high application rates of 150 and 80 mg P kg −1. The application of these products as fertilizers could have negative implications for both environmental and agronomic goals. Conversely, chemically treated fertilisers demonstrated better agronomic performance. The same agronomic target value was reached with application rates of only 20 mg P kg −1 soil for DPS and 50 mg P kg −1 soil for struvite. However, the techniques deployed revealed that these products exhibited slower rates of available and exchangeable P build-up when compared with chemical fertilisers. This suggests that these bio-based alternatives require higher application rates or earlier application times compared to conventional chemical fertilizers. Regulations providing advice on P use in agricultural soils need to account for slower P turnover in soils receiving recycled fertilizers. The IPD technique is transferrable to all wastes to examine their performance as fertilizers. © 2022 The Authors

REFLOW project

https://doi.org/10.1016/j.jenvman.2022.116702

Changes in phosphorus turnover when soils under long-term P management are amended with bio-based fertiliser

Khomenko O.; Fenton O.; Leahy J.J.; Daly K.

Geoderma, 2023

Understanding available phosphorus (P) turnover could improve sustainable P management. An isotope tracing 33P was used to measure daily P turnover rates and exchangeable P (E) in P deficient, balanced, and excess P soils from a long-term P site. Turnover under P deficient conditions was characterised by the lowest P flux predominantly from the available into the exchangeable P pools (P efflux). The P efflux in the P deficient soil was 3.7 ± 0.6 mg P/L day−1 and the inverse flux (P influx) was 1.6 ± 0.4 mg P/L day−1. Turnover rates were more than twofold higher under P balanced and surplus conditions, exhibiting an equilibrium between influx and efflux rates. The contribution of abiotic processes to P turnover was predominant in the excess P soil, whereas biotic processes dominated turnover rates under P deficient conditions. Changes in P turnover were measured following application of single superphosphate (SSP) and dairy processing sludge (DPS). Both fertiliser types increased P turnover rates and availability across all soils. After SSP application, E values plateaued between 238 and 297 mg P/L regardless of initial P status. Slower P release from DPS was evidenced by a wider range of E values (97–160 mg P/L) with slower turnover. © 2022

REFLOW project

https://doi.org/10.1016/j.geoderma.2022.116288

Nitrogen and phosphate removal from dairy processing side-streams by monocultures or consortium of microalgae

Kiani, H., Azimi, Y., Li, Y., Mousavi, M., Cara, F., Mulcahy, S., McDonnell, H., Blanco, A., Halim, R.

Journal of Biotechnology, 2023

Acid-casein production generates waste streams that are rich in nitrogen (in the form of protein and nitrate) and phosphate. This makes this type of waste very difficult to treat using conventional techniques resulting in a high amount of operating cost and costly investment. In this research, the application of single culture or consortium of microalgae for uptake of nitrogen and phosphate in the wastewater of an acid-casein factory was investigated. The waste was a 1:1 mixture of nanofiltered whey permeate and dairy processing wastewater. Monocultures of Chlorella vulgaris, Tetradesmus obloquus, Nonnochlropsis ocenica and a consortium of the three microalgae were analyzed. The results showed that the consortium exhibited more efficient nitrogen and phosphate removal compared to the individual species. The consortium was able to rapidly hydrolyse exogenous protein present in the waste medium, removing 88% of protein and breaking down complex protein molecules into simpler compounds (such as nitrate) for assimilation into the biomass. In the first fourteen days of cultivation, the rate of nitrate assimilation by the consortium biomass was lower than that of nitrate formation from protein degradation, leading to a net increase in nitrate concentration in the medium. As protein source was depleted and biomass concentration increased, however, the rate of nitrate assimilation began to exceed that of nitrate formation allowing for net removal of nitrate. The microalgae consortium was shown to successfully bioremediate all nitrates by day 21. It was indicated that Chlorella and Nannochloropsis species were responsible for nitrogen removal in monocultures. Phosphate, on the other hand, was efficiently removed by Tetradesmus. The results indicated that a consortium cultivation of three species of microalgae led to effective elimination of both nitrogen and phosphate. Combined flow-cytometry and microscopy analyses revealed that Chlorella overtook Tetradesmus and Nannochloropsis to emerge as the dominant population in the consortium by the end of the cultivation cycle. It can be concluded that the application of microalgae consortium for simultaneous recovery of nitrogen and phosphate is a promising approach for treating acid-casein wastewater.

CareerFIT Publication

https://doi.org/10.1016/j.jbiotec.2022.11.011

Hydrothermal carbonization of milk/dairy processing sludge: Fate of plant nutrients

Kwapinska M.; Pisano I.; Leahy J.J.

Journal of Environmental Management, 2023

Dairy processing sludge (DPS) is a byproduct generated in wastewater treatment plants located in dairy (milk) processing companies (waste activated sludge). DPS presents challenges in terms of its management (as biosolids) due to its high moisture content, prolonged storage required, uncontrolled nutrient loss and accumulation of certain substances in soil in the proximity of dairy companies. This study investigates the potential of hydrothermal carbonization (HTC) for recovery of nutrients in the form of solid hydrochar (biochar) produced from DPS originating from four different dairy processing companies. The HTC tests were carried out at 160 °C, 180 °C, 200 °C and 220 °C, and a residence time of 1h. The elemental properties of hydrochars (biochars), the content of primary and secondary nutrients, as well as contaminants were examined. The transformation of phosphorus in DPS during HTC was investigated. The fraction of plant available phosphorus was determined. The properties of hydrochar (biochar) were compared against the European Union Fertilizing Products Regulation. The findings of this study demonstrate that the content of nutrient in hydrochars (biochars) meet the requirements for organo-mineral fertilizer with nitrogen and phosphorus as the declared nutrients (13.9–26.7%). Further research on plant growth and field tests are needed to fully assess the agronomic potential of HTC hydrochar (biochar). © 2023 The Authors

https://doi.org/10.1016/j.jenvman.2023.118931

Release of N containing compounds during pyrolysis of milk / dairy sludge - preliminary experiental results

Kwapinska, M.

Journal of Analytical and Applied Pyrolysis, 2023

A dried dairy processing sludge (sludge from wastewater treatment of an effluent from a milk processing plant) was pyrolysed in a single-particle reactor at different temperatures from 400 ° C to 900 ° C. NH3 and HCN were measured online and offline by means of FTIR as well as by cumulative sampling in impinger bottles (in 0.05 M H2SO4 and 1 M NaOH, respectively) and analysed by photometric method. NO and NO2 were measured online using a nitric oxide analyser while N2O was measured by FTIR. Nitrogen (N) in the sludge and in the remaining char, char-N, was determined. Moreover, tar content in pyrolysis gas was measured and tar-N was determined. The results with respect to N mass balance closure are discussed. The different measurements techniques are compared. For pyrolysis at 520 °C and 700 °C nitrogen in the gas phase was mainly contained as N2 (36 % and 40 % respectively), followed by NH3 (15 % and 18 %), tar-N (10 % and 9 %), HCN (1 % and 3 %), NO (1 %) and NO2 (0.2 %). The dairy processing sludge has very specific properties with organic-N present predominantly as proteins and a high content of inherent Ca. These characteristics affected the distribution of N. The amount of char-N was higher while the amount of tar-N lower than for sewage sludge from literature, at comparable pyrolysis temperature.

https://doi.org/10.1016/j.jaap.2024.106391

Mechanism of lactose assimilation in microalgae for the bioremediation of dairy processing side-streams and co-production of valuable food products

Li, Y., Miros, S., Kiani, H., Eckhardt, H-G., Blanco, A., Mulcahy, S., McDonnell, H., Tiwari, B., Halim, R.

Journal of Applied Phycology, 2023

This study investigated the mechanism of lactose assimilation in Nannochloropsis oceanica for dairy-wastewater bioremediation and co-production of valuable feed/food ingredients in a circular dairy system (β-galactosidase and omega-3 polyunsaturated fatty acids). Mixotrophic cultivation was found to be mandatory for lactose assimilation in N. oceanica, with biomass production in mixotrophic cultures reaching a fourfold increase over that under heterotrophic conditions. Under mixotrophic conditions, the microalgae were able to produce β-galactosidase enzyme to hydrolyse lactose, with maximum extracellular secretion recorded on day 8 of growth cycle at 41.47 ± 0.33 U gbiomass−1. No increase in the concentration of glucose or galactose was observed in the medium, confirming the ability of microalgae to indiscriminately absorb the resultant monosaccharides derived from lactose breakdown. Population analysis revealed that microalgae cells were able to maintain dominance in the mixotrophic culture, with bacteria accounting for < 12% of biomass. On the other hand, under heterotrophic conditions, native bacteria took over the culture (occupying over 95% of total biomass). The bacteria, however, were also unable to effectively assimilate lactose, resulting in limited biomass increase and negligible production of extracellular β-galactosidase. Results from the study indicate that N. oceanica can be effectively applied for onsite dairy wastewater treatment under strict mixotrophic conditions. This is commercially disadvantageous as it rules out the possibility of deploying heterotrophic fermentation with low-cost bioreactors and smaller areal footprint.

CareerFIT Publication

https://doi.org/10.1007/s10811-023-03002-2

How temperature shapes the biosynthesis of polyhydroxyalkanoates in mixed microbial cultures

Palmeiro-Sánchez, T.; Graham, A.; Lens, P.N.L.; O'Flaherty, V.

Water Environment Research, 2023

Three sequential batch reactors were operated for the enrichment in microbial communities able to store polyhydroxyalkanoates (PHAs) using activated sludge as inoculum. They ran simultaneously under the same operational conditions (organic loading rate, hydraulic and solids retention time, cycle length, C/N ratio) just with the solely difference of the working temperature: psychrophilic (15°C), mesophilic (30°C), and thermophilic (48°C). The microbial communities enriched showed different behaviors in terms of consumption and production rates. In terms of PHA accumulation, the psychrophilic community was able to accumulate an average amount of 17.7 ± 5.7 wt% poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), the mesophilic 40.3 ± 7.0 wt% PHBV, and the thermophilic 14.8 ± 0.3 wt% PHBV in dry weight over total solids. The average PHBV production yields for each selected community were 0.41 ± 0.12 CmmolPHBV/CmmolVFA at 15°C, 0.64 ± 0.05 CmmolPHBV/CmmolVFA at 30°C, and 0.39 ± 0.14 CmmolPHBV/CmmolVFA at 48°C. The overall performance of the mesophilic reactor was better than the other two, and the copolymers obtained at this temperature contained a higher PHV fraction. The physico-chemical properties of the obtained biopolymers at each temperature were also measured, and major differences were found in the molecular weight, following an increasing trend with temperature.

CareerFIT Publication

https://doi.org/10.1002/wer.10934

Phosphorus fertiliser equivalent value of dairy processing sludge-derived STRUBIAS products using ryegrass (Lolium perenne L.) and spring wheat (Triticum aestivum)

Shi W.; Fenton O.; Ashekuzzaman S.M.; Daly K.; Leahy J.J.; Khalaf N.; Chojnacka K.; Numviyimana C.; Warchoł J.; Healy M.G.

Journal of Plant Nutrition and Soil Science, 2023

Background: Struvite, biochar and ash products (collectively known as STRUBIAS) derived from different waste streams are used as fertilisers in agriculture. Raw dairy processing sludge (DPS) shows promise as bio-based fertilisers, but secondary STRUBIAS-derived products need further testing as fertilisers. Aims: The objective of this study was to calculate the phosphorus mineral fertiliser equivalency (P-MFE) for some STRUBIAS products derived from DPS. Methods: Ryegrass (Lolium perenne L.) and wheat (Triticum aestivum) pot trials were used to determine the P-MFE using the apparent P recovery (APR) method for Fe-DPS and DPS-derived struvites (Struvite 1–4), hydrochars (HC1–3) and ash. Results: The tested STRUBIAS products can be divided into two groups: (1) a range of products that can (i.e. Struvite 1–3) and (2) cannot (i.e., Struvite 4, HC1–3, ash and Fe-DPS) be considered fertilisers. In the first group, the P-MFE ranged from 66.8% to 76.7% for ryegrass and from 77.9% to 93.5% for spring wheat grain. In the second group, the P-MFE ranged from 7.8% to 58.3% for ryegrass and from −34.5% to −151.3% for spring wheat grain. The negative agronomic effects of some products for wheat grain (struvite and HC) in this study were mainly caused by high Fe content, which could be overcome by improved treatment processes. Conclusions: Future policy and research must be aware that not all the DPS-derived STRUBIAS products are suitable as fertilisers and therefore need to be tested individually.

REFLOW project

https://doi.org/10.1002/jpln.202300164

"Effects of food to inoculum ratio and ultrasound pre-treatment on biogas production from dissolved air flotation waste from dairy wastewater."

Yu-Chen Liu Sandra O'Connor, Lara M. Paulo, Camilla Maria Braguglia, Maria Cristina Gagliano, Vincent O'Flaherty

Process Safety & Environmental Protection, 2023

Dissolved air flotation (DAF) waste, a byproduct with high lipid content separated from dairy wastewater, is disposed of by land spreading and causing environmental pollution. To develop a sustainable treatment for DAF waste, this study investigated the effects of food to inoculum (F/I) ratio and ultrasound pre-treatment on the anaerobic digestion of DAF waste. The biochemical methane potential (BMP) of tested DAF waste ranged from 436–566 mL CH4/g VSfed. Increasing the F/I ratio (>1.0) inhibited methane production due to long chain fatty acids (LCFA) accumulation, which high concentrations of oleate inhibited methanogenesis and delayed palmitate degradation. Ultrasound pre-treatment with 30 min pulse (10 s on/ 10 s off) and 15 min continuous operations increased soluble chemical oxygen demand in DAF waste by 82% and 52%, respectively. Moreover, continuous sonication removed 38% of LCFA due to the implosion of cavitation bubbles. The BMP of DAF waste increased by 36% after sonication with F/I ratio 3.0. However, the lag time of methane production was prolonged after sonication due to the fast release of LCFA to the bulk solution. By implementing ultrasound pre-treatment and optimizing the F/I ratio, the energy potential of DAF waste can be harnessed, leading to more sustainable practices in dairy production.

https://doi.org/10.1016/j.psep.2024.01.058

Plasma-activated liquids for mitigating biofilms on food and food contact surfaces

Zhao, Y., Bhavya, M.L., Patange, A., Sun, DW, Tiwari, B.

Comprehensive Reviews in Food Science and Food Safety, 2023

Plasma-activated liquids (PALs) are emerging and promising alternatives to traditional decontamination technologies and have evolved as a new technology for applications in food, agriculture, and medicine. Contamination caused by foodborne pathogens and their biofilms has posed challenges and concerns to the food industry in terms of safety and quality. The nature of the food and the food processing environment are major factors that contribute to the growth of various microorganisms, followed by the biofilm characteristics that ensure their survival in severe environmental conditions and against traditional chemical disinfectants. PALs show an efficient impact against microorganisms and their biofilms, with various reactive species (short- and long-lived ones), physiochemical properties, and plasma processing factors playing a crucial role in mitigating biofilms. Moreover, there is potential to improve and optimize disinfection strategies using a combination of PALs with other technologies for the inactivation of biofilms. The overarching aim of this study is to build a better understanding of the parameters that govern the liquid chemistry generated in a liquid exposed to plasma and how these translate into biological effects on biofilms. This review provides a current understanding of PALs-mediated mechanisms of action on biofilms; however, the precise inactivation mechanism is still not clear and is an important part of the research. Implementation of PALs in the food industry could help overcome the disinfection hurdles and can enhance biofilm inactivation efficacy. Future perspectives in this field to expand existing state of the art to seek breakthroughs for scale-up and implementation of PALs technology in the food industry are also discussed.

CareerFIT Publication

https://doi.org/10.1111/1541-4337.13126

Novel biorefinery process for extraction of laminarin, alginate and protein from brown seaweed using hydrodynamic cavitation

Zhu, X., Healy, L., Das, R., Bhavya, M.L., Karuppusamy, S., Sun, DW., O'Donnell, C., Tiwari, B.

Algal Research, 2023

This paper investigates a novel biorefinery process designed for the extraction of valuable compounds from brown seaweed Alaria esculenta using hydrodynamic cavitation (HDC). A two-stage process was developed to maximize the value of seaweed biomass by control of the processing time, solvent selection and HDC conditions to extract laminarin, alginate, mannitol and protein in a cascading manner, maximizing the value of seaweed biomass. After the first extraction stage using 0.1 M HCl, membrane ultrafiltration was employed to separate laminarin and mannitol. The purity of the laminarin and mannitol obtained was up to 86.57 ± 3.72 % and 40.49 ± 2.78 % with recovery rates of 55.55 ± 3.10 % and 75.90 ± 4.49 %, respectively. Ethanol precipitation was then carried out to recover sodium alginate after the second extraction stage process using 2 % Na2CO3 (w/v). The sodium alginate purity extracted by employing HDC twice (HDC-HDC) was 88.98 ± 4.70 % with a recovery rate of 65.13 ± 5.14 %. The remaining residue after the biorefinery process had an enriched protein content of 17.19 ± 1.33 %. This study demonstrates that an HDC-assisted biorefinery process can significantly ($P < 0.05$) reduce energy consumption. The laminarin extracts were further characterised by antioxidant activity, anti-inflammation activity, FT-IR, and anti-microbial activity. The laminarin extracted in this study was shown to have identical bioactive activities as the commercially available samples.

CareerFIT Publication

https://doi.org/10.1016/j.algal.2023.103243

Hydrochar from dairy sludge as phosphorus fertiliser affects greenhouse gas emissions and maize yield

Hu Y., Taghizadeh-Toosi A., Baral K.R.; Smith A.M., Khalaf N., Sommer S.G.

Acta Agriculturae Scandinavica Section B: Soil and Plant Science, 2024

Dairy processing sludge is a phosphorus (P) rich waste with a high potential to replace mineral phosphorus fertiliser in crop production, with possible enhancement of greenhouse gas emissions to the environment. Hydrothermal carbonisation is a technology that transforms the sludge into a hydrochar. The objective of this study is examining P availability of two hydrochars produced from Danish and Irish dairy sludge and their influence on greenhouse gas emissions and maize yields. The trial assessed (i) Danish dairy sludge; (ii) hydrochar derived from Danish sludge; (iii) hydrochar made from Irish dairy sludge; (iv) mineral phosphorus fertiliser; and (v) control. Emissions of nitrous oxide and carbon dioxide, soil pH, mineral nitrogen contents and crop yields were measured. Treatment with Danish dairy sludge had significantly higher cumulative nitrous oxide emissions while the emissions from both hydrochars were not significantly different compared to mineral phosphorous feriliser. Statistical modelling showed that temperature, soil nitrate content, interactions both between temperature and precipitation, and between soil moisture and precipitation were drivers for nitrous oxide emissions. There was no difference in emissions among all treatments when scaled for yield. Hydrochar may alleviate the enhanced nitrous oxide emissions in soil without constraining P availability and maize crop yields.

REFLOW project

https://doi.org/10.1080/09064710.2024.2310276

Enhancing BMP and digestibility of DAF sludge via hydrodynamic cavitation

Islam M.S.; Ranade V.V.

Chemical Engineering and Processing - Process Intensification, 2024

This study addresses fats, oils, and grease bioconversion challenges in dissolved air floatation (DAF) sludge from dairy processing waste streams. A hydrodynamic cavitation (HC) based pre-treatment method was developed for enhanced anaerobic digestion of DAF sludge. Bench-scale pre-treatment experiments were carried out using a vortex-based HC device at 20 L/min and 250 kPa pressure drop. Influence of severity of the pre-treatment (number of passes through HC device) and substrate concentration on biomethane potential (BMP) was quantified. The study revealed that soluble chemical oxygen demand (sCOD) increases with number of passes (34 % after 80 passes). Higher sludge concentration was found to increase the lag time observed in the BMP data. It was possible to tolerate 3 % VS sludge. The pre-treatment showed a notable increase in BMP, exceeding 82 % of theoretical BMP, with VS removal surpassing 73 %. The highest methane yield achieved was 756 mL/gVS of sludge. The net energy gain (after subtracting energy required for pre-treatment) was found to be more than 100 kWh/ton of sludge. The developed pre-treatment process and presented results provide a basis for the effective valorisation of DAF sludge, promoting a circular economy approach. © 2024 The Author(s)

https://doi.org/10.1016/j.cep.2024.109733

Contrasting Phosphorus Build-up and Drawdown Dynamics in Soils Receiving Dairy Processing Sludge and Mineral Fertilisers

Khomenko O., Fenton O., Leahy J.J., Daly K.

Journal of Soil Science and Plant Nutrition, 2024

Sustainable utilisation of waste from the food industry is required to transition to a circular economy. The dairy industry relies on high phosphorus (P) inputs and produces large quantities of P-rich dairy processing sludge (DPS). Recycling DPS into P fertilisers provides an opportunity to decrease the reliance on chemical P fertilisers. However, current soil nutrient management planning (NMP) is based on chemical P and does not account for recycled alternatives. A pot trial using a novel isotope pool dilution technique was used to describe build-up and drawdown cycles of P in soils fertilised with DPS. Changes in available, exchangeable, and Mehlich3 P (M3-P) pools were recorded over 36 weeks of grass growth. Results demonstrated that in the period of high P demand (12 weeks), these P pools were depleted. As crop growth and demand decreased, available P recovered through mobilisation of P from exchangeable P and M3-P reserves. DPS allowed available P to recover and build up to agronomic target levels after 24 weeks. Using DPS, build-up of available and exchangeable P was slower but P use efficiency was higher at stages of slow growth. Dairy waste created a more stable P pool which could be utilised by crops over a growing season indicating that NMP needs to account for this in the decision support for growers. Isotope studies revealed that extractive agronomic tests do not capture drawdown in P reserves.

REFLOW project

https://doi.org/10.1007/s42729-023-01585-w

Corrigendum to “Release of N-containing compounds during pyrolysis of milk/dairy processing sludge – Experimental results and comparison of measurement techniques” [J. Anal. Appl. Pyrolysis 178 (2024) 106391] (Journal of Analytical and Applied Pyrolysis (

Kwapinska M.; Sommersacher P.; Kienzl N.; Retschitzegger S.; Lagler J.; Horvat A.; Leahy J.J.

Journal of Analytical and Applied Pyrolysis, 2024

The authors regret to inform that a typo was present in the original manuscript concerning the acknowledgment of financial support for one institution. This error is rectified in this corrigendum. The correct version should read: 'This work was also supported by the Dairy Processing Technology Centre funded through Enterprise Ireland - Grant Agreement number TC/2014/0016'. The authors would like to apologise for any inconvenience caused.

https://doi.org/10.1016/j.jaap.2024.106423

First evidence for temperature's influence on the enrichment, assembly, and activity of polyhydroxyalkanoate-synthesizing mixed microbial communities

Trego, A.; Palmeiro-Sánchez, T.; Graham, A.; Umer Zeeshan, I.; O'Flaherty, V.

Frontiers in Systems Biology, 2024

Polyhydroxyalkanoates (PHA) are popular biopolymers due to their potential use as biodegradable thermoplastics. In this study, three aerobic sequencing batch reactors were operated identically except for their temperatures, which were set at 15 °C, 35 °C, and 48 °C. The reactors were subjected to a feast–famine feeding regime, where carbon sources are supplied intermittently, to enrich PHA-accumulating microbial consortia. The biomass was sampled for 16S rRNA gene amplicon sequencing of both DNA (during the enrichment phase) and cDNA (during the enrichment and accumulation phases). All temperatures yielded highly enriched PHA-accumulating consortia. Thermophilic communities were significantly less diverse than those at low or mesophilic temperatures. In particular, Thauera was highly adaptable, abundant, and active at all temperatures. Low temperatures resulted in reduced PHA production rates and yields. Analysis of the microbial community revealed a collapse of community diversity during low-temperature PHA accumulation, suggesting that the substrate dosing strategy was unsuccessful at low temperatures. This points to future possibilities for optimizing low-temperature PHA accumulation.

CareerFIT Publication

https://doi.org/ 10.3389/fsysb.2024.1375472

Research Programme: *Other*

Extraction and Characterization of Protein Concentrates from Limpets (Patella vulgata) and Peptide Release Following Gastrointestinal Digestion

Bilir, Gurkan; Khalesi, Mohammadreza; Cermeño, Maria; Fitzgerald, Richard J.; Ekinci, Deniz

Journal of Agricultural and Food Chemistry, 2022

This study investigated the characterization of proteins from the Irish limpet (Patella vulgata) and assessed the in vitro biological activities of hydrolysates obtained following gastrointestinal digestion (INFOGEST) of a limpet protein concentrate (LPC). The physicochemical properties and the digestibility of the LPC were investigated, along with the angiotensin-converting enzyme (ACE) inhibition and antioxidant activities of the LPC-digested samples. All the digested samples examined outperformed the LPC in terms of activity. Peptides were identified using LC–MS/MS after digestion. A total of 38 and 19 peptides were identified in LPC-G and LPC-GI, respectively, using a database search and a de novo approach. Most of the identified peptides had hydrophobic amino acids, which may contribute to their antioxidant and ACE inhibitory activities. The findings of this study showed that LPC has high nutritional quality with good digestibility and could serve as a potential source of antioxidative and ACE inhibitory peptides following gastrointestinal digestion.

CareerFIT Publication

https://doi.org/10.1021/acs.jafc.2c00578

In Vitro Digestibility, Biological Activity, and Physicochemical Characterization of Proteins Extracted from Conventionally and Organically Cultivated Hempseed (Cannabis sativa L.)

Khalesi, Mohammadreza; Gcaza, Luthando; FitzGerald, Richard J.

Molecules, 2023

The proteins from two conventionally (CC1 and CC2) and one organically cultivated (OC) hempseed samples were extracted (by alkaline solubilization followed by isoelectric precipitation) and compared in terms of their physicochemical, digestibility and in vitro bioactivity properties. The OC hempseed had higher total protein and lower nonprotein nitrogen content. Protein extracts showed bimodal particle size distributions, with OC showing the smallest and CC1 the largest mean particle diameter (d(0.5)), i.e., 89.0 and 120.0 µm, respectively. Chromatographic analysis showed similar protein profiles for all three protein extracts. The protein extracts were subjected to in vitro simulated gastrointestinal digestion (SGID). Degree of hydrolysis (DH) measurement showed that the highest extent of digestion upon SGID was associated with CC1 (11.0 ± 1.5%), which also had the lowest in vitro antioxidant activity. Only the OC and OC digested samples had lipase inhibitory activity. The results indicate that the cultivation method impacted the composition, physicochemical, digestibility, and biofunctional properties of hempseed proteins.

CareerFIT Publication

https://doi.org/10.3390/molecules28030915

Enzyme-Assisted Extraction of Plant Proteins

Kleekayai, Thanyaporn, Khalesi, Mohammadreza, Amigo-Benavent, Miryam, Cermeño, Maria, Harnedy-Rothwell, Pádraigín, FitzGerald, Richard J.

Green Protein Processing Technologies from Plants: Novel Extraction and Purification Methods for Product Development, 2023

Enzyme-assisted extraction (EAE) is an environmentally friendly green processing technique used to aid protein extraction from different plant sources. This is due to its mild operating conditions, reduced waste generation and low energy consumption compared to chemical and physical extraction approaches. A range of food grade carbohydrase and protease preparations have been employed to aid protein extraction/solubilisation from different plant sources by hydrolysis of the plant cell wall and the proteins therein. Different statistical tools can be employed to optimise enzyme treatment parameters including enzyme:substrate, pH, incubation temperature and hydrolysis duration to yield maximal protein recovery. While EAE facilitates protein recovery, it may also enhance the nutritional (digestibility) and techno- and bio-functional properties of the extracted proteins, particularly when using protease-assisted extraction. Combining EAE with physical techniques, e.g., ultrasonic processing, for biomass pre-treatment can enhance plant cell wall disruption with a view to enhancing protein extraction efficiency. This approach can facilitate economic feasibility by reducing the energy required and the quantity of enzyme used and, therefore, the overall cost of the extraction process. An overview of the application of EAE in protein/peptide recovery from different plant sources including oilseeds, nuts, cereals, pulses and algae is provided herein.

CareerFIT Publication

https://doi.org/10.1007/978-3-031-16968-7_6

Persian everlasting pea (Lathyrus rotundifolius L.) protein isolate as a potential protein source for food application: Effect of ultrasound-assisted extraction method on the properties of the protein isolates

Youshanlouei, Y., Kiani, H., Mousavi, M., Mousavi, Z., Tao, Y., Halim, R.

Journal of Food Process Engineering, 2024

Finding new protein sources and processes comprising targeted functional properties is crucial for the increasing global food demand. In the current paper, a new protein isolate is introduced with potential benefits based on the seeds of Persian everlasting pea (Lathyrus rotundifolius L.). Conventional aqueous extraction for the preparation of protein isolates (CPEP) was compared with pre-ultrasonic (PUPEP) and ultrasound-assisted (UAPEP) extractions, and the physicochemical and functional properties of the proteins were investigated. By the implication of ultrasound trials, protein recovery was increased from 49.88% for CPEP to 55.02% and 56.11%, for PUPEP and UAPEP, respectively. According to gel electrophoresis, no major distinction in molecular weight between protein fractions of different samples was perceived and sonication practice did not convert the primary structures of proteins. FTIR results uncovered changes in different extraction modes, implying that ultrasound could transform the secondary structures of the protein. Thermal properties and surface tension were decreased during sonication due to the conformational changes. The results of this study indicated that Persian everlasting pea protein isolate could be considered as a novel source of valuable protein and functional ingredient in the food industry.

CareerFIT Publication

https://doi.org/10.1111/jfpe.14533