IOP Institute of Physics
Food Physics Group

NEWSLETTER **February 2022**

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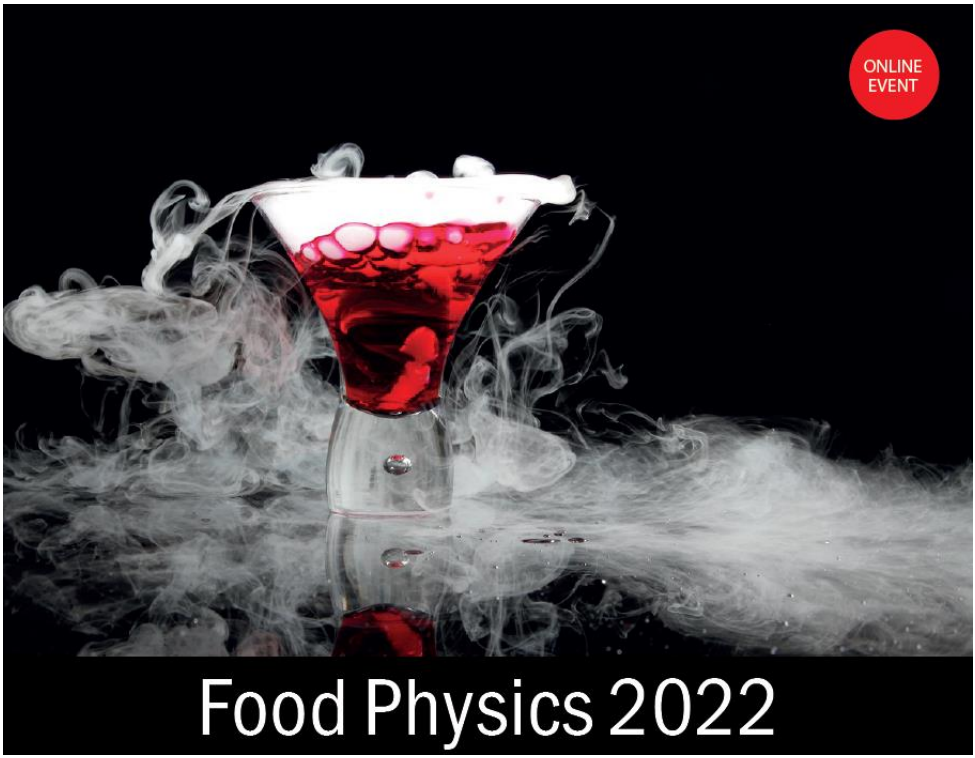


@Physicsoffood #Physicsoffood

https://www.iop.org/physics-community/special-interest-groups/food-physics-group#gref

Contents

Chair's report

Welcome to the fifth newsletter of the Food Physics group.

We have just had our sixth conference in the series "Food Physics", on-line for the second year. I truly hope next year's will be a physical event! We had even more registrations this year at 111, with a good breadth of international speakers. Read more in the conference report including the prizes for best poster and best poster presentation.

We had our second AGM. Read the AGM report for more details.

After 6 excellent conferences hosted by Universities (Sheffield Hallam 2017, Edinburgh 2018, Leeds 2020), Industrial-facing institutes (Campden BRI 2019) and the last two as virtual conferences, I'm delighted to confirm that we are already planning **Food Physics 2023.**

In October 2021, we partnered for the second time with the Royal Society of Chemistry's Food Group to run an excellent on-line programme over a full day on "Chemical and Physical Modelling of Food". Read more later in this newsletter.

Along with all the IOP's Special Interest Groups, we had our first formal committee elections in September 2021. We welcome new committee members Eddie Pelan, Peter Schuetz and Gleb Yakubov, and Zak Glover co-opted for Early Careers, who I know will enrich our Food Physics group. Many thanks to our outgoing committee members – Felix Oppong and Dough Cleaver – for their contributions.

I am particularly delighted that Gleb Yakubov has written a guest editorial for this newsletter, a very interesting read.

I also report on the creation of a new professional group (ProFSET) comprised of the Food & Drink groups of scientific groups such as IOP, IChemE and RSC.

We continue to encourage all readers to engage with Food Physics, whether to discuss joint workshops / conferences, link us to events perhaps outside our normal networks, or just to discuss application of interesting physics to solve food and drink innovation challenges.

John Bows, Chair

Guest Editorial

In 2018, an international team from Weizmann Institute and Caltech published a research article in the June 19 issue of PNAS [1]. The article, titled “The Biomass Distribution on Earth” presents a comprehensive census of the Earth’s biosphere. The mind-boggling fact is that of all mammals, by mass, 60% are domestic animals (cattle & co), 36% are humans, and only 4% are the rest of all mammals, which includes heavy whales and numerous rodents. With birds, 71% are domestic avians, like chickens, compared to just 29% wild species. Where am I going with this? The philosophical paradigm states that “Physics is Everything” [2] and our current environment is dominated by our food chain, meaning Food Physics covers a huge part of the Universe closest to us. In the last 10 years, we see how physics spearheads advances that will come to the rescue and solve the fundamental problems that have a direct impact on our food and our lives.

In this context, the concept of a Food System takes central stage. The Food System aims to achieve Food Security, Nutrition and Sustainable Development – through optimisation and in-depth understanding of the complex web of interactions spanning food primary production, food processing, consumption and nutrition and health. The fundamental challenge of uncovering complex interactions is at the core of solving global challenges and addressing environmental priorities. Here, Food Physics takes the leading role in providing the toolbox of methods to study Food Systems, but also, importantly, generating new ideas and using lateral thinking to bring ideas from other areas of Physics to help understand Food and Food Systems.

This year, Food Physics Conferences focused on key challenges that lie in the areas of food structure and its impact on nutrition and digestion, creating plant-based protein-rich foods, understanding fundamental soft matter aspects of food structure and processing, and development of new measurement techniques to benefit the research questions across the entire spectrum of the Food System: from agriculture to digestion and food oral processing. The questions of digitalisation and application of machine learning and artificial intelligence as emerging tools have been extensively discussed, with key examples in crop control and waste management.

Across all these research questions and applications, we see a common fundamental theme related to the importance of the order-disorder transitions, and how these transitions control and explain the behaviour of food systems. If we look at the problem of plant-based foods, we are living through a transformation from animal-dominated protein sources, to potentially more sustainable plant-based alternatives. The word ‘potentially’ is important here. On one side, the

evidence we currently have clearly points to the fact that the total amount of protein eaten by cattle is larger than the amount of protein they 'produce' [3]. Intuitively, this makes sense. The laws of thermodynamics tell us that the efficiency of a complete system cannot exceed 100%. On the other hand, not all proteins are made equal, and the nutritional value of animal-based proteins for humans is higher than that of common plant-based proteins. To complicate things further, we ought to realise that ruminants such as cattle and sheep, are efficient fermentation 'reactors'. It is the cow's gut microbiome that takes on a leading role of converting calorie-depleted food, like hay and straw, into the molecular building blocks used to assemble highly nutritious and calorie- dense muscle and fat tissues. So the task of creating new plant-based products brings us to the need of to choose the right plant, the right part of it and then take on the task of re-folding and re-assembling proteins to make nutritious and palatable foods, whilst keeping a close eye on the amount of 'electricity' burned in the process. Finding efficient mechanisms to control protein structuring would open enormous opportunities for boosting efficiency of making balanced and healthy plant-based foods. By understanding protein transformations during processing and in the digestive system, we can start developing efficient strategies for identifying the paths of minimum energy that afford the desired structural transitions at minimum expense.

Plant-based foods is only one example. The order-disorder transitions are at the heart of many other pertinent problems in the area of Food Systems: creating plant-based food packaging, maximising efficiency of crop use, minimising waste and optimising food structure to maximise health outcomes and support and improve public health.

Food Physics may not be absolutely "Everything", but its multi-disciplinary approach and openness to new ideas has the capacity to take us through the rough waters and overcome some key challenges we currently face in the name of a sustainable, fair and more prosperous future.

[1] Bar-On Y.M., Phillips R., Milo R. (2018) PNAS 115(25) 6506-6511.

[2] Punchline of Dr Don Lincoln from Fermilab YouTube channel, "…because, well, you know – physics is everything"

[3] Ritchie H., Reay D.S., Higgins P. (2018) Frontiers in Sustainable Food Systems 2:57.

Gleb Yakubov

Food Physics Group Purpose

Supporting research into areas of physics that impact the food sector, and encouraging collaborative research between academic and industrial physicists.

Promoting the role of physics in the food industry and ensuring that it is more widely understood that this is a field in which there are opportunities to conduct interesting and important research; promoting this fact to early career physicists and policy makers.

Providing a mechanism for physicists in the sector to feed into the IOP and have their views represented to funders and policy makers.

Activities

Organise an annual conference

Engage with physics academia / other IOP groups e.g. host joint events

Bidirectional exchange of physics and problems between industry and academia

Engage beyond IOP (e.g. IChemE, RSC, STFC Food Network+, IUK)

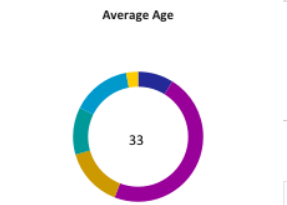
Publish newsletters

Engage early careers physicists

Added at the 2022 AGM.
Outreach to schools / STEM via food physics (note IOP Outreach Toolkit)

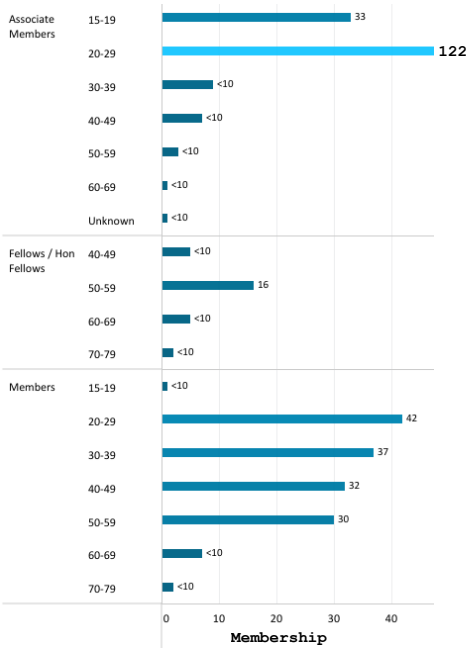
Membership Overview

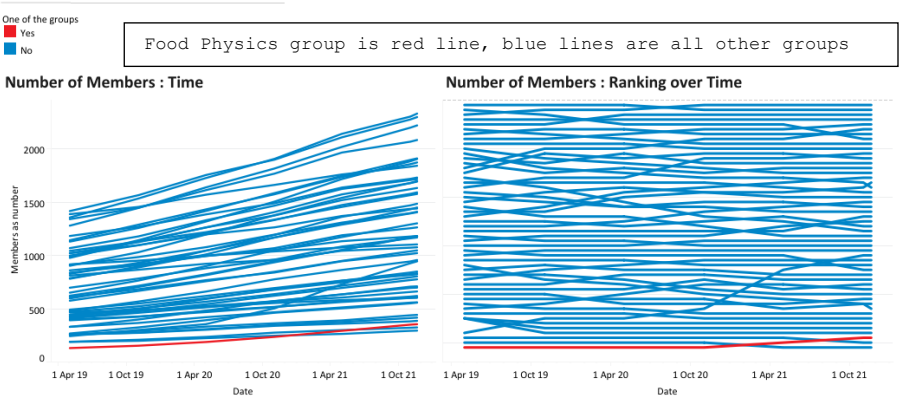
As at 1st Feb 2022, Food Physics Group had 360 members of which 33% are Female (c/w 16% for IOP Total). Average Age is 33 (51 for IOP) with 8% Fellows (15% IOP).



15-19	30	8%	
20-29	160	44%	
30-39	50	14%	
40-49	40	11%	
50-59	50	14%	
60-69	10	3%	
70-79	<10		
Unknown	<10		

Female %





By Grade. Member: 150, Fellows/Hon Fellows: 30, Associate Members: 180

Report from Food Physics Conference, 1-2 Feb 2022

Food Physics 2022 was the sixth in our annual series of conferences (previous events have been held at Sheffield Hallam, Edinburgh, Chipping Campden, Leeds and online); as last year, the conference was on-line and supported by the IOP with Ana Santos coordinating. The committee thank Ana for her great work supporting the setting up of the conference, the web site and running the meeting. There were some 111 registrants with 40-60 online at a time. In addition to our usual areas of soft-matter and measurement, this conference included sessions on oral processing and digestion, a 'hot' area 'Plant based foods' and a session on physics in agriculture research. We also introduced a session of 3-min presentations of poster introductions.

Day 1

The first session of the conference was on **Oral processing and digestion**. It opened with *Maria Charalambides (Imperial College).* She first reported measurement of the dependence of the fracture stress and modulus on the porosity of chocolate soft-solids. She then gave some data on mouthfeel, sensory and fracture measurements using a wire cutting technique. Fitting the rheological data including a ductile damage model she parameterised constitutive models for input to FE modelling; combining this with a stomach model she presented some preliminary data on the breakdown of soft solids in the stomach.

Ben Boyd (Monash Univ.) took us through a master class on the transformations of triglycerides on digestion into fatty-acids and their subsequent self-assembled liquid crystal phases. Using a stomach mimic, the team have observed the time-resolved phase transformations by sampling and passing aliquots through a small angle x-ray analysis. Cow milk triglycerides transform under digestion into diglycerides, fatty acids and monoglycerides (getting more polar along this sequence). The meso scale molecular assemblies pass through reversed hexagonal, lamellar, hexagonal structures and finally dispersed micelles. He reported data for human breast milk which in contrast formed an inverted micellar cubic phase. Further data was then given for various infant formulas and soya milk. The work is at the frontier of understanding the digestion of lipids; the relevance of the work to in-vivo depends on the assumption that digestion is faster than adsorption, preliminary data in-vivo (rats) supports this.

Anwesha Sarkar (Univ. of Leeds), reported on the tribology of plant and dairy proteins. The need for experiments with surfaces realistic of the mouth was emphasised; based on measurements of papillae on tongue surfaces she reported the development of a 3D bio-mimic for a tongue surface; matching the

modulus and surface distribution of papillae was key. These were used in tribology experiments. She reported case studies of the tribology of plant proteins; higher friction was measured for pea proteins than whey proteins due to adsorption. However, formation of microgels could reduce the pea protein friction. The final part of the talk reported results for nano-scale tribology of soft surfaces with protein adsorbed.

Lawrence Harris (Mondelez) completed the session with a review of challenges arising from adding fibre particulates to chocolate products and also the steps needed to develop products to get consumer acceptance of mouthfeel. He noted that the sensation of the process of bolus formation as well as the final bolus was important for consumer liking. Other issues of adding plant fibres into products included the need to understand their hydration during oral processing; preliminary data showed that consumers become very sensitive to levels above 10%, but this level of loading also gives rheological issues in processing.

After a lunch break, the **Poster** session followed with the 3 minute introductions and then each poster was given a breakout room which were well attended with much discussion on each poster. The 16 poster submissions reflected well the sessions of the conference, and there were 5 posters from outside the UK. Posters prizes were awarded to Pallab Kumar Borah and Mark Al-Shemmeri. Read more in the following Poster Section.

The **Plant based foods** session opened with *Atze Jan van der Groot (Wageningen Univ.)* reporting structuring into hierarchical fibre meat mimics using shear rheological techniques; exploiting shear banding and string formation; these are now being scaled up for commercial production by a spin out company. Results were shown for an example of sheared mixtures of pectin or gluten and soya protein. His team applies TD-NMR and high temperature rheological techniques to probe these structures, in particular the distribution of water in the high concentration mixtures, also identifying when structures were bi-continuous. The talk reported results for sheared Ca caseinate solutions using Small-Angle Neutron scattering to quantify the fibrous nano-scale structure: this was correlated with the mechanical properties of the bulk material.

Tim Ingmire (Quorn foods) reviewed the history of this mycoprotein based food; it is manufactured through fermentation in large vessels (30-40m tall). The sustainability of this product was reviewed. Quorn have ambitious targets for future production. To achieve this, many technical challenges need be solved; these include: optimising mass flows (sparging with gas bubbles is used to drive mass movements within the fermenters); the application of real time sensing technologies and modelling of the mechanical performance on hyphae (the

filamentous structure of fungi) length, exploiting the physics of crystal formation and crosslinking hydrogels. Currently egg-proteins are used to bind the structure – they would like to replace this with a plant based crosslinking agent. Finally, there is need to better understand and design the oral processing and digestion of these products. There were questions on whether meat mimics are the best targets; the ideal would be to get products better than meat.

Tom Reddyhoff (Imperial College) closed the session with his work on ball and plate tribological and contact-microscopy measurements of plant-proteins, in particular giving insights into the mechanisms of astringency and optimising the friction performance. He uses soft surface PDMS tongue mimics in rotating disc and ball rheometers with gap imaging; the method is to add solutions into a gap with an existing mucosal film and to measure the rheological changes. Saliva variability was a challenge. Food applications included the mouthfeel of low-calorie fizzy beverages. Results were shown for the effect of carbonation on the thin mucosal films in the gap (they remove it). Carbonation could increase friction coefficient by an order of magnitude. Results were shown for the effect of plant-based proteins on astringency: added pea, whey and casein all increased friction; noise in the tribology data was identified as due to protein particles entrained into the gap. Particle deformation and break-up of particles entrained into the gap could be observed.

A **Measurement** session ended the first day with talk by *Geoff Nash (Univ. of Exeter)* reporting on using meta-materials (e.g. a patterned gold film introducing resonances to the IR probe) to enhance FTIR-ATR (attenuated total reflection) techniques. These improve chemical detection and there are prospects for this to be used in food applications such as detection of adulteration, in-line and lab-on-chip. Examples were shown of the detection of butyl acetate and Oleic acid. Future challenges were to create chiral metamaterials for detection of chirality and increased intensity to detect single molecules by focusing to small scale.

Martin Scanlon (Univ. of Manitoba) reported a wide range of ultrasound results on bubbles in doughs, advancing the methods into real-time measurement of bubble evolution during processing; scattering from bubbles is the key physical observation. Ultrasound probing is not affected by the opacity of doughs and the responses to longitudinally polarised pulses are very sensitive to bubbles. The method was used to quantify different wheat varieties. The bubble analysis from ultrasound was validated by comparison with X-ray microtomography. The mechanical properties of doughs are very sensitive to the degree of bubbles. The talk closed with results on the production of Asian noodles in a roller production, ultrasound probes were added between roll stages. They particularly looked at the effect on doughs of Fusarium (a soil fungus)- affected grains.

Day 2

The second day opened with a session on **Measurement and agriculture**. *Sarah Rogers (ISIS, STFC Rutherford Lab.)* reviewed the applications of ISIS (Neutron), CLF (intense laser) and Diamond (X-Ray) in the food area, she introduced the STFC food network as the contact point for using these national facilities in the agri-food sector. Diamond offers (moving up scales) spectroscopy, diffraction, scattering and imaging and tomography; applications included imaging peanuts, microstructure of ice-cream under temperature cycling to measure aging, elemental mapping of nutrients in wheat grains and iron-porphyrin supplements in plant-based meats. Applications of CLF in foods included detecting rancid coconut cream and studies of catalysts in crop protection formulations. Food applications of ISIS exploited the ability of neutrons to probe light elements and isotropic substitution. This allowed imaging of root structures (see later talk). Other applications have included using a model of a leaf's waxy surface to study pesticide penetration, the texture of meat substitutes, hydration maps of sugar molecules and the stability of dairy products (using techniques by which neutrons can probe long length scales up to microns). The non-destructive nature of neutrons (in contrast in X-rays) was noted. Increasing Neutron flux was the next stage of technical development.

Sacha Mooney (Nottingham Univ.) introduced the conference to the physics of soil science, how crucial it was to the planet and human food supply and noted the challenges of reduced fertility, compaction, waterlogging and erosion. His group is focused on soil structure, hence the role of physics; X-ray tomography is his key tool. He discussed how porosity measurement could be used to quantify the effects of tillage: its impact on root development, reducing tillage being a contemporary trend in agronomy; zero tillage improves soil pore connectivity, deeper down into soil cores. Zero tillage can reduce greenhouse gas emissions by 30%. He then discussed the imaging of the rhizosphere, the soil region around the surface of roots. He showed how machine learning could be used to speed up imaging of roots with X-ray tomography, a key enabling step for the future due to the need of plant scientists to study larger numbers of replicates. Robotic methods also increase experimental throughput. A recent finding is the relevance of soil porosity local to roots via its modulation of ethylene concentration. This was related to root development in compact soils because ethylene concentration limits root growth (ethylene is a plant growth hormone modulating elongational growth). The aim is to find methods to get bio-pores deeper down to soil, to encourage deeper root growth. He finished with a field example, showing how root imaging could explain how Maize grown along with different varieties of Brachiaria shows differential performance. Discussion included the pay-off

between initial low yields with start-up of zero tillage, longer term benefits and the reduction GHG emissions,

Genoveva Burca (ISIS Rutherford) followed, she contrasted the differences between neutron and X-ray imaging of roots in soil, the former giving better imaging of roots and water, but not the mineral soil composition and soil structure available with the latter. They have developed complementary methods combining neutron and X-ray imaging. She showed several data sets including the imaging of early root growth in wheat; neutrons allow the imaging of lateral roots and the dynamics of water distribution. However, neutron signal acquisition times are long.

Malcolm Faers (Bayer) closed the session with a talk on the physics relevant to the delivery of actives from agricultural spray droplets on plant leaves. Formulations of particulate actives, oil adjuncts and water are mixed before spraying. The sensitivity of droplet wetting and spreading to surface texture has been extensively studied in the physics literature and this application exploits this knowledge base. A new trend which is motivating changes in spray formulation is the use of drones to spray, this will give lower levels of spray deposits on leaves. One key finding was that low volume sprays could deliver significant improvements on the spreading of drops if formulations included the use of surfactants tuned for different leaf surfaces, textured and non-textured. A second mechanism that influences the performance is the coffee ring effect (crystal particles of actives spread to the outer edge of a drying drop); this can separate the particles from the oil drop adjuncts that are needed to dissolve the particulate actives before diffusion into the leaves. Formulations were tuned so that the oil adjuncts are also swept to the edge of the drying drops. A second strategy was to add a yield stress component to the formulation inhibiting the coffee ring, this can also be achieved with low volume water formation (higher concentration). It was explained in the discussion that formulations are developed in which the actives are already dissolved in solvents, before mixing with water, but this can give sprays which irritate workers. Formulations in which the particulates are in oil with surfactants generally mix such that the particles disperse into water on mixing before spraying.

The final session of the conference was in the core area of **Microstructure and Soft Matter.** *Deniz Gunes (KU Leuven, ex Nestle)* gave the conference challenges remaining in two physical effects highly relevant to foods. The first was the origin and physics of anti-foaming, he identified questions of drop deformability, film rupture formation and protein adsorption, the role of emulsion aggregation and the effect of large bulk stress (e.g. as present in whipping processes). The second effect was the aging of fat crystal networks. Initially the elastic modulus of these increases over a few hours as the sub- α form changes

to the α and β-phase with high surface area; but he then gave data on longer time scales (weeks) over which the shear modulus decreases. On these time scales the aging of fat networks is driven by polymorphic changes of the β phase. As this phase changes its morphology, he suspects the network connections reduce changing the rheology – an aspect of the physics would be the presence of larger (granular objects) but with large (colloidal scale) surface area.

Elena Simone (Politecnico di Torino) reported her work on modelling crystal polymorphs for Pickering stabilisers and experiments on Oleogels. The facetted nature of crystals should give a route to designing and tuning their properties as Pickering stabilisers. Quercetin crystals were modelled. She has explored Quercetin dihydrate (needle like) and Quercetin DMSO (more plate like) (DMSO: Dimethylsulfoxide, which is food grade); the Q-DMSO was more hydrophilic. The second part of the talk concerned Oleogels (cocoa butter-sunflower oil) formed by whipping; she reported how aging was affected by the cocoa butter load and the ripening of the fat crystal network.

Delphine Huc-Mathis (AgroParisTech) reported the optimal conditions they had found for producing high internal phase emulsions using a range of uncracked vegetal by-product particles as Pickering stabilisers. The strategy was a one-step fabrication (avoiding for example fractionation). The vegetal components were sugar beet, orange, apple oat bran particles. Finding an optimal powder concentration was crucial for stability; 80:20:1 (oil:water:stabiliser) emulsions were formed; most work was done with micronized orange pomace; the microstructure was of packed facetted oil drops, more like a foam than an emulsion of spherical drops. However, success was sensitive to the oil phase: sunflower, rapeseed and paraffin worked well but olive and borage oil failed.

Maaten Schutyser (Wageningen Univ.) gave the last talk of the conference. He talked on spray drying and the physics of the surface films of droplets which develop during drying and their role in promoting hollow shell structures. They have pilot scale dryers, but also make observations on single drops drying, in particular the dependence of the onset of skin formation and the final morphology on the composition of maltol-dextrin and whey protein isolate. If the former was high in the composition the final morphology was a hollow particle, if the latter was high the final morphology was a wrinkled particle. He discussed the physics of hollow particle formation, based on the rheology of thin films; skin formation was identified by the storage modulus relative to the loss modulus. High loss modulus gave more viscous behaviour resulting in the more wrinkled final morphology, this corresponded to compositions dominated by oligomers and small sugars. Conversely a high concentration of polysaccharides gave high storage modulus and final hollow shell morphologies. These composition correlations for the lab scale measurements were successfully compared with the morphologies found in

the pilot scale, although complicated by the wide distributions of particles produced due to history within the spray dryer.

Interactions

In the report on last year's conference the pros and cons of on-line format were discussed: flexibility, getting international speakers vs lack of informal networking at meals, the late-night brain storming, the lack of face-face human bonding. Many of the talks had good following questions and discussions; we are all getting used to the on-line format. At the 2022 conference all talks were invited, and we were able to have a good spread of international speakers, but we did not have any early career speakers. The poster session was particularly successful, and we should keep the 3-min introductions, this gives many early career researchers exposure. The use of a hot topic session was a good experiment, and I would advise such sessions at future conferences. It was also clear that applications to agriculture offer much scope for physics. We again did not draw in attendees from SME and given the missions of the FP group we must redouble efforts on that.

http://foodphysics2022.iopconfs.org/home

John Melrose

Poster Session

This year we had an impressive contribution of 16 poster presentations to the conference. The poster session is an integral part of traditional conferences and provides an excellent platform for early career researchers to showcase their work and engage with the scientific community.

To adapt to the virtual format each presenter provided a three minute, pre-recorded video presentation, followed by a breakout room mediated networking session. Two prizes were available; one for best video presentation and one for best poster. New formats and ways of working brings with it fresh opportunities to innovate and deliver content in new and interesting ways, which was evidenced by all of our presenters.

One standout was Pallab Kumar Borah from the University of Nottingham, UK, who was awarded the prize for best presentation. The committee were impressed with the effective use of animation and excellent communication during his presentation on ‘Preferentially solvated polysaccharides in aqueous glycerol feature coil to rod interconversions’.

The prize for the best poster was awarded to Mark Al-Shemmeri from University of Birmingham & Jacobs Douwe Egberts, UK. The committee found Mark’s poster on ‘Positron Emission Particle Tracking (PEPT) as a Tool to Study Particle Dynamics in a Rotating Drum Coffee Roaster’ to be well scoped, concise and demonstrated a unique approach and sophisticated modelling.

The prize winners present their work in the next section.

Zachary Glover

P1	**Jamming of non-colloidal plant cell-wall particles: the role of packing, mechanical properties, and surface interactions** Panagiota Mouraka, University of Nottingham, UK
P2	**Impacts of surface defects on the dynamics of wetting and on the shape of advancing contact lines** Solomon Melides, University of Surrey, UK
P3	**Effect of crystallization conditions on the physical properties of cocoa butter-based oleofoams: a multi-technique approach** Lorenzo Metilli, University of Leeds, UK
P4	**Preferentially solvated polysaccharides in aqueous glycerol feature coil to rod interconversions** Pallab Kumar Borah, University of Nottingham, UK
P5	**Potential of Bile Salt-Containing Liposomes as Carriers of Health-Promoting Resveratrol** Aygul Can, University of Leeds, UK
P6	**Incidental Nanoparticles in Black Tea Infusion: Carriers of Bioactives Fortifying Protection on Intestinal Mucosal Cells against Oxidative Stresses** Huan Han, Zhejiang gongshang University, China
P7	**A-TEEM (Absorbance-Transmission fluorescence Excitation and Emission Matrix) for quality control and fraud identification of food and beverages** Giorgia Marucci, HORIBA, UK
P8	**The application of microrheological techniques to the characterisation of polysaccharide solutions** Adam O'Connell, University of Leeds, UK
P9	**Positron Emission Particle Tracking (PEPT) as a Tool to Study Particle Dynamics in a Rotating Drum Coffee Roaster** Mark Al-Shemmeri, University of Birmingham & Jacobs Douwe Egberts, UK
P10	**Numerical Simulations of Sintering Coupled with Heat Transfer and Application to Food 3D Printing** Pietro Rando, University of Surrey, UK
P11	**Dynamic mechanical behaviour of chocolate for simulating handling and transportation** Costas Elezoglou, Imperial College London, UK
P12	**Starch granule characterization and significance of particle-particle interactions in suspension rheology** Arnesh Palanisamy, AgroParistech, France
P13	**Saliva influences the rheological properties of semi-solid foods containing starch: a quantitative in vitro study** Anaïs Lavoisier, INRAE, France
P14	**Visualisation of pollen rehydration via deep learning** James Grant-Jacob, University of Southampton, UK
P15	**Novel Lipid Based Nanoparticles for the Stimulation of Plant-Fungal Mycorrhizal Symbioses** Iain Lawson, University of Leeds, UK
P16	**A low-intensity ultrasound study of the relationship between dough rheological properties and wheat free asparagine concentration** Susane Trevisan, University of Manitoba, Canada

Poster Prize Winners

Best Poster Prize to **Mark Al-Shemmeri**

Positron Emission Particle Tracking (PEPT) as a Tool to Study Particle Dynamics in a Rotating Drum Coffee Roaster

Coffee's in-cup flavour & aroma is determined by its physicochemical development during roasting. The coffee's development depends on the applied time-temperature profile (i.e., rate of heat transfer), which in turn depends on the system's particle dynamics. This study focused on coffee bean particle motion in a rotating drum roaster, tracked using Positron Emission Particle Tracking (PEPT) - a non-invasive technique that can characterise flow behaviour in granular systems. Process parameters such as the drum's rotation speed, coffee's batch size and bean density (i.e., roast degree) influence particle dynamics and were thus varied to understand their impact on flow patterns. Occupancy profiles revealed a dense bean bed of high occupancy, as well as a dilute region corresponding to beans in-flight. Both Bean Bed Mass Fraction ($BBMF$) and median particle velocity ($\widetilde{v_p}$) were affected by bean density, rotation speed and batch size such that: (i) coffee of greater roast degree (with greater bean volume) decreases $\widetilde{v_p}$, yielding a greater $BBMF$ (ii) a larger batch size decreases $\widetilde{v_p}$, inducing greater $BBMF$ (iii) a higher rotation speed increases $\widetilde{v_p}$, reducing $BBMF$. PEPT provides real particle motion data for granular systems that can be used for physics-driven models to relate heat transfer and particle dynamics and thus optimise time-temperature roasting profiles.

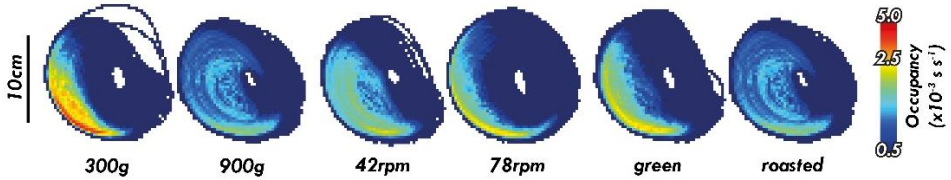


Fig 1: Effect of batch size *Fig 2: Effect of drum speed* *Fig 3: Effect of roast degree*

Mark is undertaking a PhD in Simulation of coffee roasting using physics-driven models. Understanding coffee's physicochemical behaviour during roasting is key to the optimization of the applied time-temperature profile and control of the coffee's development. The EngD project aims to develop a comprehensive understanding of coffee roasting through models and predictive tools based on

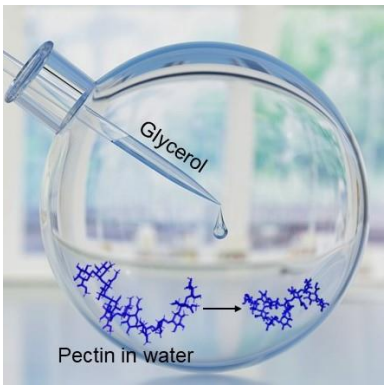
both empirical and mechanistic approaches at the batch (i.e., macro) and bean (i.e., micro) scale. Ultimately, the development of more accurate and robust physics-driven models of coffee roasting will support virtualisation of the process. The EngD project is funded by the EPSRC through the Centre for Doctoral Training in Formulation Engineering at the University of Birmingham (grant no. EP/L015153/1) and Jacobs Douwe Egberts.

Mark Al-Shemmeri

Best Poster Presentation Prize to **Pallab Kumar Borah**

Preferentially solvated polysaccharides in aqueous glycerol feature coil to rod interconversions.

Pallab is a Research Fellow at the Soft Matter Biomaterials & Biointerfaces Group, University of Nottingham in the UK. He received his PhD in 2021 and his current work relates to the design of anisotropic food structures. He is passionate about biopolymers, small molecules, digestion, and molecular dynamics. The present work was carried out in collaboration with Massey University, University of Queensland, and Motif FoodWorks.



The design of structured and functional food materials relies on our ability to tune polysaccharide chain conformation, internal length scale and self-association, which are intrinsically coupled with solvent properties. In our work, we utilised pectin (a ubiquitous plant biopolymer) as a flexible high-molecular weight model polysaccharide, to study the role of aqueous glycerol on polysaccharide chain conformation and excluded volume-to-hydrodynamic interactions. Using a complementary combination of steady-state shear and extensional rheology, intrinsic

viscosity, and molecular dynamics simulations, we observe that an increasing glycerol fraction in the solvent leads to a conformational change in the polysaccharide from coil to rod-like chains. An increasing radial probability distribution of water in the first solvation shell is also observed, whilst glycerol remains preferentially excluded. Based on the thermodynamic unaffordability of such an exclusion, a geometric argument is postulated whereby the incompatibility in the system is reduced by decreasing the area of polysaccharide chain-solvent contact through enhancement of chain self-association. Our work sets the foundation for future research in rheology and nonequilibrium dynamics of polysaccharide-solvent interactions in governing macroscopic rheological behaviour and presents new sets of opportunities for designing structured and functional foods.

Pallab Kumar Borah

Food Physics AGM

The AGM was held on 2nd February 2022 after the close of the conference.

Present: Committee: John Bows (Chair), John Melrose (Treasurer), Rob Farr (Secretary), Martin Whitworth; Becky Smith, Marco Ramaioli, Megan Povey, Daniel Hodgson, Peter Schuetz, Gleb Yakubov, Arwen Taylor, Zacchary Glover, Eddie Pelan. Others: Ana Santos and 16 conference attendees (total 30 on Zoom)**.**

The Chairman welcomed all to the AGM.

1. Previous AGM mins. The 2021 AGM mins were approved.

2. Chairperson remarks and discussion from attendees. Congratulations and thanks were expressed to John Melrose and Ana Santos for organising a very successful and enjoyable 2022 conference. There was appreciation for including agriculture as a topic, to round out the full spectrum of applications of physics to food. This now includes everything from farm to manufacture to digestion; and nutrition to health. The conference was well-attended, with 111 registrations; however people dipped in and out for different talks, so the highest simultaneous attendance was around 59, which could have been higher. The poster session was a great success, with many more posters than last year (16) and all of high quality.

3. Chairperson's report. John Bows described the role of the group, in terms of research into all areas of physics that are relevant to the food sector. **Eddie Pelan proposed** that the group's mission should be extended to include education and outreach to STEM pupils at secondary schools. This was seconded by John Bows, and approved by the AGM.

4. Committee elections and introductions by new committee members. Gleb Yakubov, Zacchary Glover, Peter Schuetz and Edie Pelan introduced themselves to the group. Three committee positions will come up for election in 2022, as John Bows, Beccy Smith and Zak Glover (who is on a one-year co-opted position) will reach the end of their current terms.

5. Treasurer's report. John Melrose presented the 2021 accounts. These were dominated by the February meeting, and beyond this there were no claims, none for committee travel as all meetings were on-line. Provisional 2022 accounts were similar. The cost of covering student registrations at the 2022 conference was

covered by the usual £1500 conference subsidy request to the IoP. Accounts were approved by the AGM (proposed by John Melrose, seconded by Rob Farr).

6. Food Physics Group activities. John Bows reported on recent and forthcoming activities:

- The 2021 RSC/IoP "2nd conference on Chemical and Physical Modelling in Food" was a success in November. It was only a one-day event (in contrast to the 2-day event in 2020). The proposal is to invite Robert Cordina (the organiser from the RSC side) to a committee meeting to discuss future collaboration. The feeling in the room was that a biennial conference may suit the availability of speakers.
- John Bows presented ProFSET, which is a meeting together of professional food bodies from different disciplines, including the IoP Food Physics group. There are no current plans for a joint meta-conference, but this has not been ruled out.
- John Melrose reminded the room that nominations for the IoP business awards are now open (nominations close on 14th Feb).
- Martin Whitworth advertised the "Food-Powered Business Q&A" panel discussion, which will be on 4th Feb (online), with contributions from FP committee members.
- John Bows will start the process of preparing the 2022 FP newsletter.
- The 2023 conference was briefly discussed. The feeling was that a face-to-face conference is very much preferred. Marco Ramaioli has previously mentioned his interest in organising this in France, and remains open to this possibility. This will be discussed at the next FP committee meeting.

7. AOB. A question was raised about how best to contact speakers at the conference. If this proves difficult (and most speakers should be easy to hunt down), then Ana Santos can facilitate.

Rob Farr

Food Physics Committee at external events during 2021

Usually committee members are active presenting their research at various external events from conferences to career fairs, often with a strong food physics content.

Unsurprisingly, there was little opportunity in 2021 for this, apart from the joint Chemical & Physical Modelling of Food virtual conference. Read the conference chair's report in this newsletter.

The IOP run a Business, Innovation and Growth series of events to bring together, provide support and raise the profile of physics-based innovation and businesses across the UK and Ireland. On 4th February 2022, a 1hr virtual panel discussion on **Physics-powered businesses Q&A – Food and Drink Sector Food** was led by the Food Physics Group. Panellists were:

- John Bows (panel chair), Gleb Yakubov and John Melrose from the Food Physics Group
- Richard Bray (patent attorney at Appleyard Lees)
- Sally Eldeghaidy (Research Fellow at Nottingham Uni)
- Chris Danks (Innovation Lead of the Transforming Food Production challenge at UKRI)

A lively discussion followed between panellists and attendees on a range of themes: innovation and R&D activity, investment and funding for innovation, fostering collaboration, access to key facilities and skill gaps.

John Bows

Chemical and Physical Modelling of Food conference

Following on from the success of the first Chemical & Physical Modelling of Food Conference in 2020, organised jointly by the RSC's Food Group and the IOP's Food Physics Group, a second conference was held on 12 October 2021. Due to the ongoing pandemic this was once again held online, which however helped increase the reach of this conference. Indeed, registered delegates hailed from 24 different countries, including Canada, USA and Brazil, multiple European countries, Nigeria, Kenya, Iran, India, Korea and New Zealand.

The speaker's list was also international, with these being based in the UK, USA and Ireland, with a blend of both industrial (Nestlé, Mondelēz, PepsiCo, RSSL and Schrödinger Materials) and academic (Technical University Dublin, University of Reading and University of Sheffield) speakers.

The topics covered were similarly wide-ranging. Physics-based talks included models for infant feeding via milk bottles, moisture diffusion during jelly candy stoving, hot fill processing to predict food safety quality, and the effect on the flow properties of dairy powders. Chemistry-based talks included models on the molecular release in coffee brewing, the formation of Strecker aldehyde during kilning of barley malt and flavour molecule binding and encapsulation by starch using Molecular Dynamics.

As in 2020, the conference was very well received, with positive feedback from the delegates.

Conference website with programme and abstracts:

https://www.rsc.org/events/detail/47066/2nd-chemical-and-physical-modelling-of-food

Robert Cordina
Chair, RSC Food Group

ProFSET

Having reached out to the IOP in 2015 to co-found what became the Food Physics group in 2017 (see Newsletter #1 for the group history), I realised that other professional body groups such as IChemE, IMechE, IFST etc. also have their own food & drink special interest groups, but we tend to be fairly siloed in our professional skill areas and external engagement, and therefore as a collective we lack impact at a national level. This in contrast to most innovation projects where multi-disciplinary R&D is standard practice.

So in 2018, I reached out to the food groups of several professional bodies in the UK with the idea of creating a new group of these individual groups. After a couple of years and several discussions and meetings, we gained critical mass and a consensus that this was a good idea. In 2020 we reconnected in earnest and established ProFSET – Professional Food Science, Engineering and Technology Group – with the following Group Goal and Objectives:

> To act as the group representing members of scientific, technical and engineering professional bodies in food and drink:
> - being a single, informed voice to influence and support government, media and the public
> - providing opportunities for collaboration, knowledge sharing and cooperation across industry and academia
> - promoting the industry as an exciting career path and supporting the development, education and training of professionals

During 2022, we are developing strategies to deliver these objectives and will update via the group's LinkedIn page, where the group leadership can also be contacted. ProFSET currently consists of these groups:

John Bows

Finally Physics

Finally, we highlight exciting food physics stories, experiments, features …

Neutrons and Food 6, 16-19 May 2022 Online Workshop Hosted by CIQuS, IMSS & KEK Japan.
https://www-conf.kek.jp/nf6/

Culinary fluid mechanics and other currents in food science
https://arxiv.org/abs/2201.12128

The Kitchen Pantry Scientist – physics experiments
https://kitchenpantryscientist.com/category/physics-experiments/

Physics of Fluids – Kitchen Flows
https://aip.scitation.org/topic/special-collections/kf2021?SeriesKey=phf

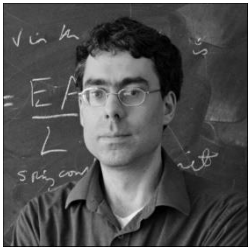
CDT in Soft Matter and Functional Interface newsletter – sometimes food items. Aug 2021 edition contains a feature on Megan Povey.
https://soficdt.webspace.durham.ac.uk/news/

The BBC World Service series “The Food Chain”
https://www.bbc.co.uk/programmes/p028z2z0/clips

The BBC series “Inside the Factory” continues to feature several food factories including malt loaf and tortilla chips, some interesting physics at work …
https://www.bbc.co.uk/iplayer/episodes/b07mddqk/inside-the-factory

Group Committee

John Bows, Chair
PepsiCo



Dr Rob Farr, Secretary
Jacob Douwe Egberts

Dr John Melrose, Treasurer

Dr Beccy Smith
Mondelez International

Prof Megan Povey
Leeds University

Dr Daniel Hodgson
University of Edinburgh

Dr Arwen Tyler
Leeds University

Dr Martin Whitworth
Campden BRI

Prof Gleb Yakubov
Nottingham University

Dr Eddie Pelan
Birmingham
University

Dr Peter Schuetz
Unilever

Dr Marco Ramaoli
INRAE

Dr Zak Glover
Arla Foods
(co-opted, Early Careers)

John Bows is an employee of PepsiCo, Inc. The views expressed in this newsletter are those of the author and do not necessarily reflect the position or policy of PepsiCo, Inc.

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The Institute of Physics, 37 Caledonian Road, London N1 9BU.

Tel: +44 (0)20 7470 4800
Fax: +44 (0)20 7470 4848