14th International Workshop on Molecular and Physical Gastronomy (IWMPG 14)

AgroParisTech, 22 place de l'agronomie, 91120 Palaiseau (France),
email: icmg@agroparistech.fr

15-16 May 2025

Organized by:
AgroParisTech-INRAE International Centre for Molecular and Physical Gastronomy :
https://icmpg.hub.inrae.fr/international-activities-of-the-international-centre-of-molecular-gastronomy/iwmpg-workshops

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Building safe and sustainable food for the future: scientific and technological innovation".

INRAE ICMPG AgroParisTech

Organization Committee:

Róisín Burke (Technological University Dublin, Ireland), Alan Kelly (University College Cork, Ireland), Christophe Lavelle (CNRS/MNHN, France), Hervé This vo Kientza (AgroParisTech-INRAE, France), Dan Vodnar (UAVSM of Cluj-Napoca, Romania)

For physical attendance :

Campus Agro Paris-Saclay, 22 place de l'agronomie, 91120 Palaiseau (France). Room to be given (B3.43)

Participants will have to reach the main entrance, and to get a pass at the desk.

For connection:

For the 15th:

Time: May 15, 2025 06:15 AM Paris
Join Zoom Meeting
https://agroparistech-fr.zoom.us/j/98678581184?pwd=6M86rLh2SJG7mDaDCu16IAXYQa5shP.1
Meeting ID: 986 7858 1184
Passcode: 708291

For the 16th:

Time: May 16, 2025 06:00 AM Paris
Join Zoom Meeting
https://agroparistech-fr.zoom.us/j/98957596862?pwd=a1Eva4S7bAruSDBRIBPMljcsJdaoRR.1
Meeting ID: 989 5759 6862
Passcode: 540820

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Purpose of the Workshop

« La gastronomie est la connaissance raisonnée de tout ce qui se rapporte à l'homme en tant qu'il se nourrit» (Gastronomy is the reasoned knowledge about man's nourishment)
Jean Anthelme Brillat-Savarin (1755-1826)

Writing about the application of the chemistry to the art of cookery:
« In what art or science could improvements be made that could more powerfully contribute to increase the comforts and enjoyments of mankind »
Sir Benjamin Thompson, Count Rumford, (1753-1814)

« "Molecular gastronomy is the scientific activity consisting in exploring the mechanisms of phenomena occurring during dishes preparation and consumption."
Hervé This and Nicholas Kurti, (1988)

The above quotations from the writings of two founders of Molecular and Physical Gastronomy express in a nutshell **the spirit and the objectives of the Workshop:** the emphasis will be on gastronomy rather than nutrition, on domestic and restaurant cooking rather than industry.

The object of this workshop will be to bring together a group of scientists to discuss collectively the science behind the practices carried out in the kitchen.
What is a workshop?
The *Oxford English Dictionary* defines a workshop as "a meeting at which a group of people engage in intensive discussion and activity on a particular subject or project".
Workshops, similar to seminars, are usually much smaller than conferences – a workshop can be an element of the conference structure.
Workshops typically tend to be:

- Interactive
- Educational

- Conversational

May we also point out that, as the name IWMPG « N. Kurti » indicates, this is a workshop and that **participants are encouraged to show experiments**.

Talks should preferably less than 20 min, so that discussion is promoted (of course, one can have more slides in order to be ready for the discussion).
The primary goal is not to make speeches, but to give the information that can make a basis for active discussion in all scientific directions: materials and methods, results, interpretations, consequences, scientific strategy.

Also, as workshops are more informal than conferences, we could keep the visio links open during the break and lunches, so that discussions can go on, and one could discuss other questions than suspensions during such times.

Mind that the texts from talks can be submitted as manuscripts for proceedings in the *International Journal of Molecular and Physical Gastronomy* (https://icmpg.hub.inrae.fr/international-activities-of-the-international-centre-of-molecular-gastronomy/journal-of-molecular-and-physical-gastronomy).

Schedule

Wednesday May 14, evening:

After 17.00 and up to 19.45: Get together, and Cremant.
Metting point: Hervé This office E1.915, Campus Agro Paris Saclay, Palaiseau.

Dinner nearby: 19.30

Thursday May 15:

9.00-10.00 : Session 1, Opening session

1. Hervé This: Introduction (MPG, the IWMPG, active workshops)
2. Roisin Burke: A brief overview of the presentation topics.
3. Dan Vodnar: Organization of the workshop

Presentation of the participants

10.00-12.30, Session 2 (Chairperson: Roisin Burke)

1. Agathe Tanchoux, Hervé This vo Kientza, Delphine Huc-Mathis : Unfractionated vegetal shells: it foams!
2. Hervé This vo Kientza : Complexity degree within the DSF framework (Building food and food constructivism ; can we use a degree of construction?)

Q/A, Discussion

Lunch nearby

14.00-15.30 Session 2, on 3D, 4D, 5D and 6D food printing (Chairperson: Hervé This)

1. Charlotte Dumoulin : Practical demonstration of 3D printing

2. Roisin Burke et al : Designing and developing a novel culinary dish incorporating colour changing ingredients and 4D technology

Q/A, Discussion

15.30-16.00 Break

16.00-17.00 Session 3 (Chairperson:)

1. Marta Stachnik : 3D-printed edible spoon to reduce waste
2. Charlotte Dumoulin, Laurena Masbernat, Taise Tonazzio, Sophie Berland, Giana Almeida, Camille Michon, Valérie Guénard-Lampron, Cassandre Leverrier : 3D printing of flour-based inks using a soft matter approach

Q/A, Discussion

Friday May 16:

09.00-11.00 Session 4 (Chairperson: Reine Barbar and Roisin Burke) Education session : Building food for the future: bridging the gap between education, inclusive gastronomy, interculturality and sustainability

This session aims to discuss and reflect on current and future initiatives in education that address the challenges related to safe and sustainable food, while integrating issues related to inclusive gastronomy, intercultural dynamics between educators and students, and discussing the contribution of artificial intelligence and its limitations.

Different levels of education could be discussed, from school to university and lifelong learning. Local, European and international projects and initiatives are encouraged

- What knowledge is relevant in today's world? And how?
- How can we respond to environmental and societal issues, between disciplinary specialisation and the need for interdisciplinarity?
- What are the new roles and positions for all in education and training ecosystems? What are the possible forms of relationships?
- How can we enable the different actors in educational ecosystems to open up their fields of action and move towards a collective approach?
- Can students learn without interacting with each other?
- What are your experiences with Artificial Intelligence in Education (AIED)? could it facilitate interactive and adaptive learning environments for learners of all ages, across all domains?

Share a topic you would like to discuss, based on a concrete example or educational challenge you are facing. The discussion will be in a brainstorming/discussion format rather than a formal presentation of findings. The idea is to co-create some ideas coming from experiences in the educational field.

9.00-9.30:

Roisin Burke : The role of 'Digital Education' in TU Dublin (new bank of case studies being created which will provide a means through which to record, promote,

showcase and share with others the learning and teaching tools that academic staff find effective), part of WP4 of the Tradinnovation programme.

9.30-10.05:
Reine Barbar and Bruno Leite : Implementation and experimentation of Erasmus+ Tradinnovation PBL : lessons and projections.

10.05-10.20: Break

10.20-10.40 :
Anu Hopia, Nora Logren and Nanna Rintala : Development of new Baltic herring products to meet the preferences of younger consumers

10.40-11.00 :
Linda Sellou : From Kitchen to Lab: Learning Spectroscopy Through Food Analysis

11.00-11.15 : break

11.15-12.15 Session 5 on special foods (Chairperson: José Miguel Aguilera)

1. Lachlan Bryse Maddaford : Food for Space : The Need to Investigate Effects of Gravity for the Development of Fermented Foods in Space

2. Zeynep Delen Nircan and Patricia B. O'Hara : Sustainable Olive Packaging and Processing

3. José Miguel Aguilera : Food and gastronomy from the end of the world

Q/A, Discussion

13.30-15.30 Session 6:

1. Volker Hessel, Irin Parvin, Long Van Duc Nguyen: AI & Digital Twins: The future of Disease- and Pollution-Free Farming.
2. José Miguel Aguilera : What do we know and are doing to feed the very elderly?
3. Bruno Leite : Food from seaweed: A sustainable solution for a world facing food shortages
4. Christophe Lavelle : Food for tomorrow, should we learn from the past?

15.30-15.45 : Break

14.45-17.30

Session 7 (Chairpersons: Hervé This, vo Kientza, Roisin Burke, Christophe Lavelle, Dan Vodnar)

General discussion about:
- Discussion of the next topic
- International Journal of Molecular and Physical Gastronomy, with members of the Editorial Board

Abstracts

What do we know and are doing to feed the very elderly?

José M. Aguilera,
Department of Chemical and Bioprocess Engineering, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, Santiago, Chile.
jmaguile@uc.cl

Very old people and centenarians are rapidly becoming an increasing proportion of the world's population. As with baby foods, these people require special foods tailored to their nutritional, physiological, psychological, and socio-economic conditions. The presentation will emphasize that the enjoyment of life for the elderly depends largely on what they eat (a learned experience). Advances will come from scientific knowledge of materials science (e.g., gelation, emulsification, and controlled release of nutrients and flavors) and experiences with culinary techniques such as deconstruction and molding, and emerging ones like 3D printing, and note-by-note cooking.

Food and gastronomy from the end of the world

José M. Aguilera,
Department of Chemical and Bioprocess Engineering, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, Santiago, Chile, and Cape Horn International Center (CHIC), Universidad de Magallanes, Puerto Williams, Chile.
jmaguile@uc.cl

The sub-Antarctic Magellan region of Chile in Patagonia is the southernmost zone of the planet and one of the most inhospitable areas in the world. This presentation will cover unique historical events related to food and hunger, local foods and dishes, culinary practices, and biocultural traditions. A pre-conceptual framework (PCF) to develop local food and gastronomy in this region will be advanced. Recent gastronomic initiatives to implement this PCF at the Cape Horn International Center in Puerto Williams (Chile), including a gastronomy laboratory, will also be described.

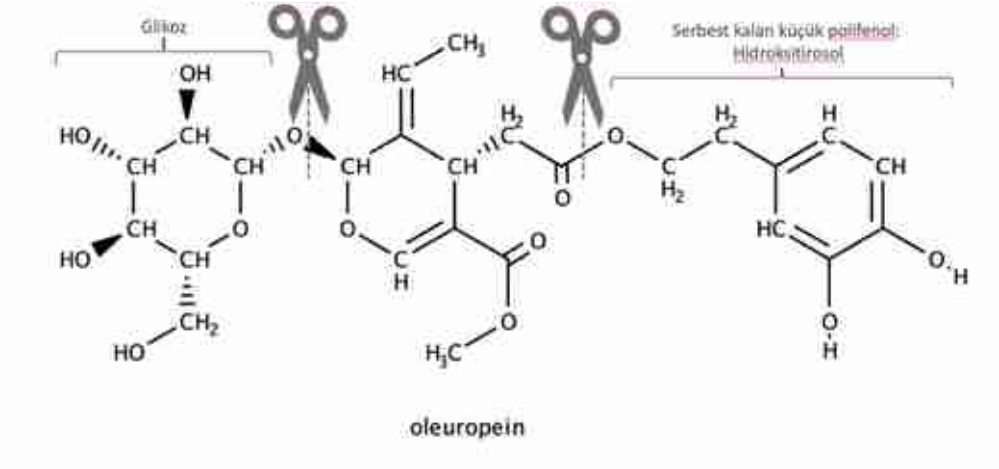
Designing and developing a novel culinary dish incorporating colour changing ingredients and 4D technology

Róisín Burke*, Rachel Cooney, Ben Fitzgerald, Charlotte Lambe, Rosie Muldowney and Pierce Prendergast.
School of Culinary Arts and Food Technology, TU Dublin, Grangegorman, Dublin 7, Ireland.
*Corresponding author, roisin.burke@tudublin.ie

The evolution of food manufacturing through 3D printing has expanded with the development of 4D printing technology and opened new possibilities in culinary applications. Compared to conventional 3D printing, 4D printing incorporates time as a new dimension, allowing for dynamic modifications to food structures. Self-assembly and reactions to external factors such as pH, moisture content, or temperature are examples of these alterations.
Results will be discussed of the design and development of a culinary dish which includes colour changing ingredients and 4D printing technology. The three elements of stimulus-responsive materials, a stimulus and time were essential factors to incorporate into the design of the printed food. Anthocyanins were chosen as a smart material, which could change colour instantly in response to a pH stimulus. A recipe which incorporated anthocyanins from purple cabbage mixed with a potato starch gel was 3D printed in a feather shape and sprayed with a lemon juice, and rosemary flavoured vodka liquid which was prepared using a rotary evaporator in a kitchen. The 3D printed feather instantly changed from a purple colour to a red colour.

Sustainable Olive Packaging and Processing

Zeynep Delen-Nircan[1], and Patricia B. O'Hara[2],
1. Sabancı Üniversitesi, İstanbul, Türkiye
2. Amherst College, Amherst, MA USA



oleuropein

Cultivated olives (*Olea europaea L.*) taste extremely bitter when sampled directly off the tree. The bitter taste that dominates the flavor profile even in the most mature "raw" olives comes from polyphenols, predominantly oleuropein, that serve to protect the unripened fruit from predators such as birds and insects. Polyphenols are healthy in low doses and toxic in high doses.

For millennia, humans have treated the fruit from olive trees to make them edible. These treatments transform the bitter polyphenols into neutral or sweeter tasting compounds. An ancient method still in use today is to brine the olive, using concentrated salt solutions or just salt itself to affect the transfer and produce "natural" olives. Alternatively, olive fruit can be transformed into table olives by the Spanish method, in which caustic alkali solutions are used to break down the polyphenols. Microorganisms that flourish in the saline or alkaline environments complete the transformation of the olives. Both methods result in highly saline or alkaline waste streams. The residual salt can be a problem for those on a low salt

diet. Several packaging and processing projects are underway to address these concerns and will be discussed [1].

Hurma Olives at Atılay İleri's Ab-u Hayat Farm

Natural biodegradation methods exist that takes advantage of microbial fermentation. In several unique geographic locations, olives can be found that are naturally debittered on the tree. Studies have identified several related fungi responsible for the natural debittering process [2] which is very sensitive to the microclimate. These olives; the Turkish *Hurma* [3], the Greek *Throubo,* and the Tunisian *Dhokar [4],* can be eater right off the tree. The natural process is extremely sensitive to winds, temperature, and rainfall. It is difficult to establish as a reliable source of the de-bittered olive which is much healthier since no salt was used, and much cleaner since no caustic solutions are produced in waste streams. Efforts to bioengineer this fungus to make it more robust would be very beneficial to both human and environmental health.

References

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3D printing of flour-based inks using a soft matter approach

Charlotte Dumoulin, Laurena Masbernat, Taise Tonazzio, Sophie Berland, Giana Almeida, Camille Michon, Valérie Guénard-Lampron, Cassandre Leverrier

UMR SayFood, AgroParisTech, 22 Place de l”agronomie, 91120 Palaiseau.
E: charlotte.dumoulin@agroparistech.fr

If one is able to print 3D structures from many edible materials, the understanding of the structuring mechanisms, their links with the rheology of the materials and its printability is not achieved. The objective of this work was to investigate the impact of the rheological behavior on the printability of flour-based inks. A wide range of food matrices based on cereal and legume flours (6 flours) mixed with fruit and vegetable purées (5 purees) was prepared through a thermomechanical process. Model matrices, made of starch and hydrocolloids were also studied. The structural parameters are described using laser granulometry and optic microscopy. The gelatinization state of the starches was evaluated using DSC. The rheological behaviour (flow and oscillatory measurements) was investigated prior and after the thermomechanical treatment and the quality of printing was measured through image analysis. This study shows that the properties of the continuous phase, in particular its sugar content and pH, influence the gelatinization temperature of starch, as described in literature. The bulkiness conditions the flow behaviour. Depending on the state of bulk, the addition of hydrocolloids in the continuous phase may either increase the viscosity of the matrices or lubricate the contacts between particles, inducing a decrease in viscosity. By proposing calculation hypotheses to approximate the volume fraction of the matrices, it has been possible to model the evolution of viscosity as a function of volume fraction for wheat flour-based matrices of varying compositions from non-gelatinized to gelatinized.

AI & Digital Twins: The future of Disease- and Pollution-Free Farming

Volker Hessel, Irin Parvin, Long Van Duc Nguyen
1 School of Chemical Engineering, University of Adelaide, Australia
2 ARC Centre of Excellence Plants for Space, University of Adelaide, Australia

Imagine multiple experts simultaneously informing food producers about fighting crop pests and diseases as well as improving farm productivity and sustainability through reducing CO2 emissions and nutrient and pesticide pollution. Currently this is inefficient process, but it could be with the power of machine-learning. This approach will drive rapid decision-making and outcomes for producers without them needing to crunch through data sets and information. This is investigated in the AEA project led by the University of Adelaide, “Digital Twins in Agriculture: Virtual Farm Model for Enhancing Crop Health, Productivity, and Sustainability”. Alongside the University of Adelaide, organisation partner Serafino Wines , a renowned South Australian Family owned and operated Wine Company situated in the McLaren Vale Wine region, will play a key role in this initiative. Led by CEO, Cavaliere Maria Maglieri , Serafino Wines will contribute by conducting field tests using sensors on their vineyards. These sensors will be installed and operated by a team led by Professor Harpinder Sandhu of the Federation University Australia and their collaborators Constellation Technologies, Melbourne . The data will provide crucial information to support the project’s goals of protecting viticulture and canola, while defending crop pests, and reducing pollution, and improving crop health, sustainability and productivity.

From Tradition to Innovation: The Case of Baltic Herring

Anu Hopia and Nora Logrén
Nutrition and Food Research Center, University of Turku, Finland

Traditional food preservation techniques such as acid-induced pickling have long been embedded in cultural practices, particularly in the Nordic region where Baltic herring (Clupea harengus membras) is commonly preserved using acetic acid. While this method ensures microbiological safety, the resulting strong vinegary flavor may limit consumer acceptance, especially among younger generations. To respond to evolving taste preferences while maintaining food safety, this presentation rethinks pickling through the lens of molecular gastronomy. The study also aligns closely with the core idea of the TRADINNOVATIONS project (web page of TRADINNOVATIONS), which seeks to scientifically renew culinary traditions "from tradition to innovation".

Molecular gastronomy, as defined for example by Burke et al. (2016), investigates the physical and chemical transformations of ingredients during culinary processes. Rather than industrial food processing it focuses on the craft of dish preparation. This scientific perspective offers an opportunity to reinterpret traditional methods like pickling by understanding the molecular mechanisms behind flavor, texture, and safety.

In the first phase of the development process Logrén et al. (2022) explored the use of food-grade weak acids, namely citric, lactic, malic, and tartaric acids, as alternatives to acetic acid. By carefully controlling the pH (maintained below 4.20), the acids' effects on protein denaturation, enzymatic activity, and lipid oxidation were investigated. The outcome was a range of microbiologically safe, nutritionally balanced pickled products with novel sensory profiles. Importantly, the sensory evaluation demonstrated that alternative acids produced milder, more nuanced flavor profiles and modified textures.

By applying the tools of molecular gastronomy this study contributes to the science-based renewal of traditional fish preservation. It reflects TRADINNOVATIONS' core

objective: to respect heritage while fostering sensory and nutritional innovation grounded in scientific understanding.

Building on the science-based renewal of pickled Baltic herring using weak acids, the next step of our innovation path explored how cultural reframing can further enhance consumer acceptance. Informed by the TRADINNOVATIONS ethos and grounded in the scientific insights of molecular gastronomy, we developed a series of fusion dishes that blended the citric acid–treated herring prototype with elements from global fish-centric food cultures. By evaluating these novel dishes in multisensory environments and examining both intrinsic (e.g., appearance, taste, texture) and extrinsic (e.g., context, description) factors, we demonstrated how scientific, sensory, and cultural elements can intersect to sustainably revalorize a declining traditional ingredient (Logrén et al 2025).

In the workshop, the authors invite participants to explore how molecular gastronomy can serve as a tool for renewing traditional food practices. Using the case study of Baltic herring pickling, we'll examine how scientific principles—such as acid strength, protein denaturation, and sensory profiling—can inspire culinary innovation while respecting cultural heritage. In dialogue with the TRADINNOVATIONS project, we'll reflect on the role of science in safeguarding tradition, enhancing sustainability, and inspiring novel sensory experiences. Participants are encouraged to critically engage with the possibilities and limits of applying molecular gastronomy in real-world culinary and cultural contexts. Topics will include how fusion cuisine can act as a scientific canvas for innovation, and how molecular understanding can guide ingredient and technique choices. We may also explore the balance between intrinsic sensory properties and extrinsic cues—such as context, presentation, and narrative—in shaping consumer perception. Finally, we'll consider the potential of multisensory design and repeated exposure to shift unfamiliar foods toward cultural familiarity and acceptance.

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Web page of TRADINNOVATIONS project https://icmpg.hub.inrae.fr/international-activities-of-the-international-centre-of-molecular-gastronomy/tradinnovation/project/project

Seaweed as Food: A sustainable solution for a world facing food shortages

Bruno Moreira-Leite

The accelerating pressures of climate change, population growth, and resource scarcity have led to increasing concerns over global food security [1]. In this context, seaweed emerges as a promising, underexploited resource with the potential to contribute significantly to sustainable food systems [2]. Rich in essential nutrients, including proteins, dietary fibers, vitamins, and minerals, seaweeds offer a highly nutritious profile with low environmental impact [3]. Unlike terrestrial crops, seaweed cultivation does not require arable land, fresh water, or synthetic fertilizers, making it an efficient and eco-friendly option in a world facing land degradation and water scarcity [4].

This communication explores the viability of seaweed as a mainstream food ingredient and its integration into food products. It examines the nutritional benefits of various macroalgae species (brown, red, and green) and their potential to enhance food stability, shelf life, and palatability. Furthermore, it addresses the socioeconomic and environmental advantages of scaling up seaweed aquaculture, including carbon sequestration, marine biodiversity support, and livelihood generation in coastal communities [5].

Recent studies within the Molecular Gastronomy Lab at NOVA FCT highlighted the potential of seaweeds as functional and flavor ingredients in the development of innovative food products rooted in tradition and familiarity. Macroalgae species from the central Portuguese coast, such as *Porphyra sp.* and *Saccorhiza polyschides*, have shown high contents of minerals, fibers, and proteins, while being low in calories, making them suitable for incorporation into healthy diets [6]. Modified atmosphere packaging (MAP) was found to effectively preserve the physicochemical and microbiological quality of two species of seaweed (*Ulva lactuca* and *Porphyra umbilicalis*) [7]. Plant-based fermented cashew nut cheese alternative enriched with *Chondrus crispus* and *Porphyra sp.* demonstrated enhanced mineral content (*e.g.*, calcium and iron) and greater flavor complexity [8]. Similarly, the inclusion of

Palmaria palmata and *Ulva* sp. in traditional semi-hard Mediterranean-style goat cheeses improved the nutritional profile and mitigated the strong “goaty” flavor, increasing consumer acceptance [9]. Additionally, chocolate formulations enriched with “kombu” (*Saccharina japonica*), “nori” (*Porphyra* sp.), and “sea lettuce” (*Ulva rigida*) were well accepted by Portuguese consumers – particularly those with kombu and nori – which were associated with umami, green tea, and dried fruit flavor notes, respectively [10], [11]. Collectively, these findings reinforce the role of seaweeds as valuable ingredients to enhance the nutritional and sensory properties of diverse food matrices, while contributing to more sustainable dietary alternatives.

However, despite its potential, the adoption of seaweed in Western diets remains limited due to unfamiliarity, taste preferences, and regulatory challenges [12]. This work highlights the need for innovation in product development, sensory adaptation, and public education to overcome these barriers. By leveraging seaweed’s multifunctionality and sustainability, the food industry can move toward more resilient, climate-smart food systems. As the global population approaches 10 billion by 2050, seaweed may play a critical role in diversifying food sources and mitigating the risk of future food shortages.

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Food for tomorrow: should we learn from the past?

Christophe Lavelle
CNRS / INSERM / National Museum of Natural History / Sorbonne University, Paris, France

Human species evolved with the invention of cooking, that is to say by developing this unique activity (among living being) which consists of transforming food BEFORE consuming it. To do this, our ancestors learned to cut, cook and ferment the food they gathered, fished and hunted. Then, we started to grow plants and raise animals, and finally, much more recently, to crack, extrude, refine, hydrogenate the raw materials provided by agriculture... so many transformations which, paradoxically, mark the end of cooking... And therefore, the decline of humanity?
The question is raised as to whether a return to the past is possible (desirable?), and if so, under what conditions.

Inclusive Gastronomy as Pedagogical Practice: Reimagining Portuguese culinary heritage through food innovation

Bruno Moreira-Leite, Paulina Mata

This pedagogical project, developed within the framework of the TradInnovations Erasmus+ initiative and the Master's in Gastronomic Sciences (NOVA FCT), integrates the curricular units Hydrocolloids in Food and Development of New Food Products. It invites students to reimagine traditional Portuguese dishes through the lens of inclusive gastronomy — that is, adapting culinary heritage to address the specific dietary needs of populations with restrictions (e.g., allergies, dysphagia, plant-based diets, religious prescriptions, etc.). Using hydrocolloids as functional and textural agents [1], each group selects a traditional recipe and modifies it based on scientific, nutritional, and cultural criteria.

The pedagogical design emphasizes research-based learning [2], interdisciplinary collaboration, and the articulation of theory and practice in food innovation. Students carry out historical and ethnographic research, nutritional assessment, ingredient substitution, sensory analysis, and prototype testing. The final outputs include a scientific article (to be submitted to the *International Journal of Molecular and Physical Gastronomy*), a conference-style oral presentation, and a scientific poster to be presented at the European Researchers' Night, held at "Pavilhão do Conhecimento – Ciência Viva", a Science Museum in Lisbon.

This approach not only promotes active and experimental learning, but also fosters critical engagement with food systems, sustainability, and cultural identity — aligning with current calls for more inclusive, innovative, and socially responsive food education [3], [4].

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The Need to Investigate Effects of Gravity for the Development of Fermented Foods in Space

Lachlan Bryce Maddaford
1. School of Chemical Engineering, University of Adelaide, Australia
2. Andy Thomas Centre for Space Resources (ATCSR), Adelaide Australia
Room A210, Engineering Annex
The University of Adelaide, Adelaide, South Australia, 5005, AUSTRALIA
E: lachlan.maddaford@adelaide.edu.au

Access and variety of food in space is limited. Sustainable space habitation and exploration necessitates the supply of nutritional food. Fermentation processes can create a variety of space-suitable products which address the challenges of synthesis, resource availability and nutrient restriction presented by the environment. Bread, cheese, and beverages could all be sustainably produced in space using modified fermentation techniques, appropriate for reduced convection environments. The nutrient and texture profiles of these products may be meaningfully different to their terrestrial counterparts due to changes to the gravity dependent phenomena during their production. Understanding the effect of gravity on production process and product quality will be crucial for food sustainability and security beyond Earth.

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From Kitchen to Lab: Learning Spectroscopy Through Food Analysis

Linda Sellou
Department of chemistry, Faculty of Science,
National University of Singapore, Office: S16-04-11
Tel: (65)-6516-6628
Email: chmsll@nus.edu.sg

Integrating hands-on activities into analytical chemistry enhances student engagement and understanding. This project focuses on food analysis using FTIR, Raman, UV-Vis, and fluorescence spectroscopy in an analytical chemistry module. Students bring their own food samples, decide on analytical approaches, and compare their results with literature. They reflect on their findings, challenges, and learning experiences. These activities develop instrumental skills, data interpretation, and critical thinking, bridging spectroscopy concepts with real-world food chemistry. This presentation explores curriculum design, learning outcomes, and challenges, demonstrating how food provides a relatable context for students to construct meaningful scientific connections.

3D-printed edible spoon to reduce waste

Marta Stachnik[1], Eija Kulju[2], Oskar Laaksonen[3]

[1] Nutrition and Food Research Center (NuFo), University of Turku, Finland

[2]Chemical Engineering and Common studies, Turku University of Applied Sciences, Finland

[3]Department of Life Technologies, University of Turku, Finland

Correspondence**:** mastac@utu.fi

Keywords

3D printing, circular economy, edible cutlery, rheology, food sidestreams, sustainability

Single-use plastic cutlery contributes significantly to environmental pollution, prompting the need for sustainable alternatives. This study explores the feasibility of 3D food printing to transform food production sidestreams into edible spoons, supporting circular economy principles. Six dough formulations (food inks) were developed using brewer's spent grain, fruit pulp, and pressed cake from seed oil extraction. Rheological properties were assessed to evaluate printability, while the printed spoons underwent water and oil absorption tests, solubility analysis, and sensory evaluation.

Rheological analysis showed that the food inks exhibited shear-thinning behavior, becoming more fluid during extrusion (phase shift angle from 14° to 80°) but lacking sufficient structural recovery post-printing (from 7.4% to 35.4%), affecting shape retention. Both storage (G') and loss (G'') moduli showed significant recipe-dependent variations. Water absorption tests indicated that the spoons absorbed significant moisture, doubling their weight within 24 hours, while oil absorption remained minimal – on average 20% increase in weight. Sensory evaluations revealed that spoons made from fruit pulp were the most acceptable in appearance and taste, while some formulations exhibited bitterness and textural inconsistencies.

This study highlights the need for functional additives to improve the mechanical properties and sensory appeal of 3D-printed edible cutlery. By valorizing food

industry sidestreams, this research contributes to sustainable food innovation and waste reduction.

Unfractionated vegetal shells: it foams!

Agathe Tanchoux [1], Hervé This [1] and Delphine Huc-Mathis [1]
[1]*Université Paris-Saclay, INRAE, AgroParisTech, UMR SayFood, 91120 Palaiseau, France Presenting author e-mail: agathe.tanchoux@agroparistech.fr*

Keywords: foam, up-cycling, multi-scale strategy

The global dietary transition requires the identification of more sustainable food systems that align with consumer demand for natural and “clean-label” products [1]. By-products valorization is a key strategy to reduce food losses and waste while promoting a circular bioeconomy. Although often destined for energy recovery, these by-products remain rich in valuable compounds (proteins, fibers, antioxidants, etc.), now targeted through extraction techniques.

Our research aims to evaluate the foaming potential of an underexplored biomass: plant shells [2]. A key aspect of this approach is their direct utilization without extraction, purification, or chemical modification. Three by-product flours were investigated: green pea hulls, yellow pea shells, and pistachio shells. Despite higher soluble content (2 to 4 times greater) in pea hull powder, only yellow pea and pistachio shell powders generated foams when suspended in water (5%). A sparging test revealed the following performance ranking: yellow pea shells > pistachio shells >>> pea hulls (Figure 1). The maximum foam height was significantly higher for yellow pea shells compared to an egg white reference solution. These findings are unexpected, as no foaming properties have been previously reported for these by-products in literature.

NMR analysis identified phosphatidylcholine among the soluble compounds in pistachio shell powder, while yellow pea shells exhibited a high protein content. The contribution of both soluble compounds and insoluble particles (Pickering stabilization mechanism?) is currently under investigation to better understand their foaming potential.

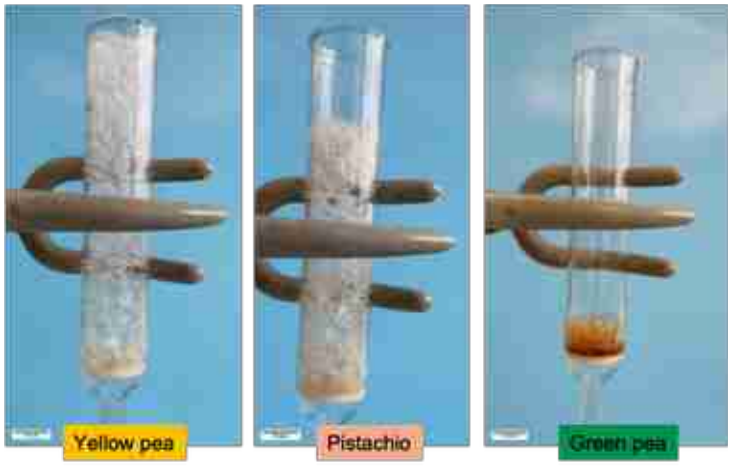

Figure 1. Foaming test of the 3 by-products by the Bikerman method

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How to rank food systems (in order to study them rationally)

Hervé This, vo Kientza
Inrae-AgroParisTech International Centre of Molecular and Physical Gastronomy
22 place de l'agronomie, 91120 Palaiseau (France)
T: +33 6 86 49 89 01
E: herve.this@agroparistech.fr

For gels [1] or for suspensions [2], “classes” of increasing complexity were introduced in the calculation of all possible systems, as described with the dispersed systems formalism (DSF) [3]. However, whereas (1) free enthalpy was used for ranking the operators used in this formalism [4], and (2) ordering of NPOS formulas was used for the classification of classical French sauces [5], no link was made with these proposals and the one of classes.
Here we shall show that the Kolmogorov complexity cannot be used for ranking dispersed systems, and that the number of phases should be used instead. This leads to a new and more comprehensive proposal for writing down the formula describing the systems, taking into account the idea of descending order [6] and decreasing orders of magnitudes [7].

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