

# 14<sup>th</sup> International Workshop on Molecular and Physical Gastronomy (IWMPG 14):

**Building safe and sustainable food for the future: “scientific and technological innovation”.**

## Book of Abstracts

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### Abstract

The 14th International Workshop on Molecular and Physical Gastronomy took place the 15th and 16th of May 2025, in AgroParisTech, 22 place de l'agronomie, 91120 Palaiseau (France), The topic was: “Building safe and sustainable food for the future: scientific and technological innovation”.

It was organized by the AgroParisTech-INRAE International Centre for Molecular and Physical Gastronomy under the patronage of the Académie d'agriculture de France (<https://icmpg.hub.inrae.fr/international-activities-of-the-international-centre-of-molecular-gastronomy/iwmpg-workshops>)

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**Keywords**

workshop, molecular and physical gastronomy, sustainability, future foods.

**Introduction**

The object of this workshop was to bring together a group of scientists to discuss collectively the science behind the practices carried out in the kitchen, specifically in relation to “Building safe and sustainable food for the future: scientific and technological innovation”. During the two days of the workshop, a wide range of discussions took place among attendees from around the globe. A diverse, interesting and important range of topics included food foams, dispersed systems formalism (DSF), 3D and 4D printed food design and development, spectroscopy for analysis, fermented foods in space, sustainable olive packaging and processing, food and gastronomy from the end of the world, the role of AI and digital twins for disease and pollution-free farming, feeding the elderly, from tradition to innovation which included the specialized topics of seaweed as food, baltic herring, reimagining portuguese culinary heritage through food innovation, and food for the future: should we learn from the past. As well as discussions on these topics there was a demonstration of 3D food printing, by Charlotte Dumoulin a Ph.D. student from AgroParisTech, France.

A session of the workshop included educational aspects such as building online digital resources for project-based learning assignments and implementation and experimentation of the Erasmus+ Tradinnovation project which uses project-based learning as a teaching and learning method.

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*Figure 1. Some of the participants of the 14th International Workshop of Molecular and Physical Gastronomy. 1. Anu Hopia (University of Turku, Finland), 2. Marija Badanjak Sabolović (University of Zagreb, Croatia), 3. Suzana Rimac Brnčić (University of Zagreb, Croatia), 4. Patricia O'Hara (Amherst College, Amherst, MA 01002, U.S.A.), 5. Róisín Burke (TU Dublin, Ireland), 6. Herve This vo Kientza (INRAE-AgroParis Tech International Centre for Molecular and Physical Gastronomy, AgroParisTech,,France), 7. Dan Vodnar (University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, Romania), 8. Linda Sellou (National University of Singapore, Singapore), 9. Agathe Tanchoux (AgroParisTech, France), 10. Reine Barbar (L'Institut Agro, Montpellier, France), 11. Charlotte Dumoulin, (Université Paris-Saclay, INRAE, AgroParisTech, UMR SayFood, France), 12. Bruno Moreira Leite (University NOVA FCT, Portugal), 13. José Miguel Aguilera (Pontificia Universidad Católica de Chile, Santiago, Chile). Others participants were online and in presence on different days (<https://icmpg.hub.inrae.fr/content/download/1660/10728?version=2>).*

### Unfractionated vegetal shells: it foams!

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### 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 (Jadhav et al., 2024). 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 (Karimi et al., 2021). 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.

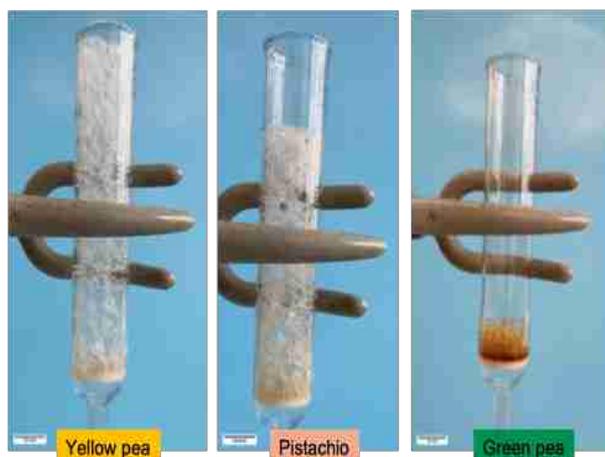


Figure 2. Foaming test of the 3 by-products by the Bikerman method.

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.

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Karimi A, Kazemi M, Samani SA and Simal-Gandara J. 2021. Bioactive compounds from by-products of eggplant: Functional properties, potential applications and advances in valorization methods, *Trends in Food Science & Technology*, 112, 518-531

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

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#### Keywords:

dispersed systems, formalism, complexity

For gels (This, 2016) or for suspensions (This vo Kientza, 2022) "classes" of increasing complexity were introduced in the calculation of all possible systems, as described with the dispersed systems formalism (DSF) (This, 2007). However, whereas (1) free enthalpy was used for ranking the operators used in this formalism (This vo Kientza, 2021), and (2) ordering of the formulas from the "non periodical organizational space formalism" was used for the classification of classical French sauces (This, 2008), 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 (This Vo Kientza, 2025) and decreasing orders of magnitudes (This *et al.*, 2021).

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Figure 3. This artificial orange is made of "degennes", i.e. spherical structures made a calcium alginate gellified "skin" enclosing seasoned orange juice (from the French chef Pierre Gagnaire). Its NDSF formula is  $D_2(W_1xS_1) \setminus [(d_2(w_2 x s_2) @ d_0(w_3))]$ .

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

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**Keywords:**

3D food printing, 4D food printing, innovative food, food design

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.



*Figure 4. 3D printed pastry 'duck', colour changing mousse and 4D printed 'duck feather'.*

### 3D-printed edible spoon to reduce waste

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#### 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.

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

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#### Keywords:

cereal and legume flours, rheology, physical chemistry, structure

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.

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Proceedings

**Building online digital resources for project-based learning assignments**

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**Keywords:**

digital, education, project-based learning, *Tradinnovations*

the work packages.

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<https://icmpg.hub.inrae.fr/international-activitiesof-the-international-centre-of-moleculargastronomy/tradinnovation/tradinnovation>

The School of Culinary Arts and Food Technology of the Technological University Dublin (TU Dublin) is a partner of the EU+ *Tradinnovations* project, which focuses on the study of recipes using project-based learning in an interdisciplinary environment. As part of the *Tradinnovations* project students and staff from EU partners in the disciplines of Food science, Nutrition, Food Engineering and the Social Sciences and Humanities work on project-based learning topics which aim to support innovation within the local food heritage of each country and adapt these recipes to specific vulnerable populations needs (malnutrition among elderly and Alzheimer population, challenges in obesity among young people, dietary needs of pregnant women and young children, ...).

An original set of hybrid teaching and learning tools is proposed with the aim to improve the food culture and skills of students while fostering their intercultural and intergenerational (among vulnerable populations) interactions. These shared tools will include online databases of stakeholders, recipes and educational resources and these are jointly being built by TU Dublin and some of the partners as an outcome of some of



Figure 5. Partners of the Tradinnovations project.

Proceedings

**Implementation and experimentation of Erasmus+ Tradinnovation PBL : lessons and projections.**

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**Keywords:**

Erasmus+, project-based learning, inclusive gastronomy, societal needs

The *Tradinnovations* project (2023-2026), funded by the European Union via Erasmus+, brings together 6 European partners and 9 associates to develop an innovative pedagogical approach. The project is based on the scientific analysis of traditional recipes and culinary heritages, while integrating inclusive innovation. Through partnerships with local stakeholders and experts and a project-based learning approach, students revisit traditional recipes to adapt them to the needs of vulnerable populations.

*Tradinnovations* is a multi-disciplinary program designed to create a three-way interaction between students, educators and socio-economic stakeholders. It brings together a wide range of expertise and disciplines, combining food engineering, culinary sciences, molecular & physical gastronomy and humanities, to build a teaching methodology enriched by all the dimensions that make up the act of "feeding oneself". After a first year in which a rich survey was carried out on the perception of tradition and innovation, the proposal of educational pathways was carried out with the start of development of an educational platform containing supporting resources. A step-by-step learning guide supports the project-based learning approach. This year, various implementation experiments in different countries are taking place simultaneously.

In the scope of this second year, several

questions are raised and could be discussed during the workshop based on all countries implementation experiences:

- lessons learned till now
- how to better integrate the use of educational platform in Project-based learning approach?
- how to stimulate intercultural interactions among students, any events/seminars online to be implemented?
- are communities of practices among students, educators and socioeconomic stakeholders possible to pursue at long term?
- what kind of different types of articles based on students projects and educational sciences related to the project's activities could be submitted
- how could the project dynamic be maintained after the erasmus+ ending and the role of advisory board

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**From Tradition to Innovation: The Case of Baltic Herring**

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**Keywords:**

Molecular gastronomy, acid-induced pickling, sensory profiling, traditional food innovation, fusion cuisin, ; multisensory design

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 4.2), 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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**From Kitchen to Lab: Learning Spectroscopy Through Food Analysis**

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**Keywords:**

education, hands-on, chemistry, analysis

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.

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**The Need to Investigate effects of gravity for the Development of Fermented Foods in Space**

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**Keywords:**

microgravity, in situ resource utilization, fermentation, process engineering

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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## Sustainable Olive Packaging and Processing

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### Keywords:

fermentation, food science, olive

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 phenols, predominantly oleuropein, that serve to protect the unripened fruit from predators such as birds and insects. Phenols 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 phenols 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 (Tübitak, 2025)L

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 (Sozbilen and

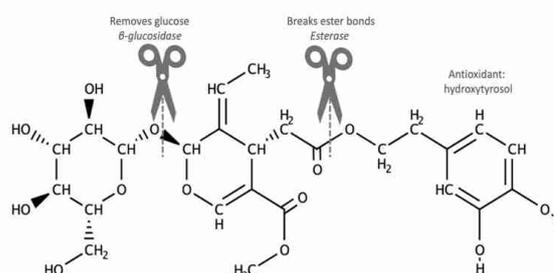


Figure 6. Oleuropein in olives gives rise to its antioxidant properties and bitter flavor. The figure shows a stick drawing of the molecule and the bonds that are broken during the debittering process.

Baysal, 2016) which is very sensitive to the microclimate. These olives, the Turkish Hurma (Susamci *et al.*, 2017), the Greek Throubo, and the Tunisian Dhokar (Rigane *et al.*, 2013), can be eaten 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.

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**Food and gastronomy from the end of the world**

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**Keywords:**

Patagonia, gastronomy laboratory, biocultural gastronomy, wild berries

The sub-Antarctic Magellan region of Chile in south-west Patagonia is the southernmost zone of the planet and one of the most inhospitable areas in the world. This presentation covers historical events related to food and hunger (including Darwin's 6-month stay and Shackleton's rescue of the crew from his Endurance expedition to Antarctica), as well as unique foods (wild berries and mushrooms) used as food and medicine, typical local dishes, culinary practices, and biocultural traditions. A pre-conceptual framework (PCF) for developing local food and gastronomy initiatives in this region is proposed. Recent efforts to implement this PCF at the Cape Horn International Center in Puerto Williams (Chile), including the establishment of a gastronomic engineering laboratory, are described.

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*Figure 7. The author and local chefs of restaurant Worus in Puerto Williams, the southernmost town in the world, are experimenting in the gastronomic engineering lab at the Cape Horn International Center.*

**Proceedings**

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

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**Keywords:**

AI, crop health, digital twins, disease control, machine learning, pollution mitigation

Imagine multiple experts simultaneously informing food producers about fighting crop pests and diseases as well as improving farm productivity and sustainability through reducing CO<sub>2</sub> 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 Australia's Economic Accelerator 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.

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<https://doi.org/https://doi.org/10.1016/j.atech.2022.100083>.

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

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**Keywords:**

elderly, food, consistency, 3D printing, note by note cooking

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.

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

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**Keywords:**

Seaweeds, Nutritional Value, Functional Ingredients, Flavour Ingredients, Sustainability, Innovative Food Products

The accelerating pressures of climate change, population growth, and resource scarcity have led to increasing concerns over global food security (UN, 2019). In this context, seaweed emerges as a promising, underexploited resource with the potential to contribute significantly to sustainable food systems (Tiwari and Troy, 2015). Rich in essential nutrients, including proteins, dietary fibers, vitamins, and minerals, seaweeds offer a highly nutritious profile with low environmental impact (MacArtain *et al.*, 2007). 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 (Buschmann *et al.*, 2017).

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 (Rebours *et al.*, 2014).

Recent studies within the Molecular Gastronomy Lab at NOVA Faculdade de Ciências e Tecnologia 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 (Milinovich, 2021). Modified atmosphere packaging (MAP) was found to effectively preserve the physicochemical and microbiological quality of two species of seaweed (*Ulva lactuca* and *Porphyra umbilicalis*) (Moreira-Leite *et al.*, 2023). 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 (Campos *et al.*, 2024). 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 (Campos *et al.*, 2025). 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 (Salgado *et al.*, 2023; Salgado *et al.*, 2024). 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 (Mouritsen *et al.*, 2021). 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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**Inclusive Gastronomy as Pedagogical Practice: Reimagining Portuguese culinary heritage through food innovation**

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**Keywords:**

Inclusive Gastronomy, Culinary Heritage,  
Hydrocolloids in Food, Innovative Food Products,  
Research Based Learning

This pedagogical project, developed within the framework of the *TradInnovations* Erasmus+ initiative and the Master's in Gastronomic Sciences (NOVA Faculdade de Ciências e Tecnologia), 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 (Phillips and Williams, 2009), each group selects a traditional recipe and modifies it based on scientific, nutritional, and cultural criteria.

The pedagogical design emphasizes research-based learning (Healey and Jenkins, 2009), 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 (Mohammadi *et al.*, 2023; de Bie and Bruns, 2024)

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**Proceedings**

**Food for tomorrow: should we learn from the past?**

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Lavelle, C. 2025. Demain, des pilules à la place des repas ? L'aide-soignante, 39(265) : 10-1.

**Keywords:**

Paleo diet, food future, transformation

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 so, our ancestors learned to cut (about 3 million years ago), cook (about 1 million years ago) and ferment (about 10 000 years ago) the food they gathered, fished and hunted. Then, we started to grow plants and raise animals (about 10 000 years ago), and finally, much more recently (about 100 years ago), 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. To (try to) answer this question, we need to consider natural AND cultural issues, which means dig into material science (physics, chemistry, biology, agronomy, physiology) as well as "human" science (history, geography, sociology, psychology). The fact that people need calories....and pleasure should not be forgotten!

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Roisin Burke, Alan Kelly, Christophe Lavelle, Herve This vo Kientza and Dan Vodnar are the organizers of the International Workshops of Molecular and Physical Gastronomy.