The 18th International Hydrocolloids Conference

Presented by

The Japanese Society of Food Hydrocolloids

The International Hydrocolloids Society

The 18th International Hydrocolloids Conference

Mar 31-Apr 2, 2026, Tokyo, Japan

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The 18th International Hydrocolloids Conference

Mar 31-Apr 2, 2026, Tokyo, Japan

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The 18th International Hydrocolloids Conference

Mar 31-Apr 2, 2026, Tokyo, Japan

Dear Colleagues,

We are pleased to welcome you to the 18th International Hydrocolloids Conference in Tokyo, Japan, March 31 to April 2, 2026. The conference is hosted by the Japanese Society of Food Hydrocolloids.

The theme of the conference is “Future Hydrocolloids for Sustainable Solutions in Food and Life Sciences”. Within this thematic framework, the conference will facilitate discussions among international experts on the following topics:

- Innovative hydrocolloid design for delivering optimal nutrition and functional foods
- Bioactive polysaccharides for human health
- Physical properties of food hydrocolloids for enhanced product development
- Behavior of food biopolymers during digestion
- Polysaccharide structures and their impact on gut microbiome
- Functional hydrocolloids for plant-based dairy and meat alternatives.
- Innovating with alternative proteins in new product development.
- Role of hydrocolloids in pharmaceuticals and health/personal care products

We trust you will enjoy the visit to Tokyo in early spring to feel the breath of new lives including cherry blossoms and inspire the next scheme by sharing research ideas on hydrocolloids at this conference. This conference will also offer excellent networking opportunities, allowing participants to connect with industry and explore potential collaborations.

I look forward to welcoming you in 2026, early spring in Tokyo.

Sincerely,

Conference Chair:
Professor Shingo Matsukawa, PhD
Tokyo University of Marine Science and Technology
Chair of the Japanese Society of Food Hydrocolloids

Committees

Local Organizing Committee:

Chair: Shingo Matsukawa

Co-chair: Yasuki Matsumura, Mitsutoshi Nakajima, Katsuyoshi Nishinari

Members (the Japanese Society of Food Hydrocolloids): Koki Ryo, Takao Nagano, Kazuhiko Yamatoya, Isao Kobayashi, Makoto Nakauma, Makoto Takemasa

Members (External Experts): Sayuri Akuzawa, Daisuke Ishii, Takashi Kuda, Yoko Nitta, Motoyoshi Kobayashi, Lester Geonzon, Takumi Umeda, Hiroyuki Kozu, Jieting Geng

Directors of the International Hydrocolloids Society:

Chair: Steve W. Cui, Canada

Members: H. Douglas Goff, Canada; Mingyong Xie, China; Stefan Kasapis, Australia

18th International Hydrocolloids Conference, Mar. 30-April 2, Tokyo University of Marine Science and Technology Shinagawa Campus, Tokyo, Japan

Plenary, Honorary and Invited Speaker Biographies

Plenary Speakers

Tuesday, March 31

Professor Eiichi Saitoh

Senior Advisor, Fujita Gakuen

Professor Emeritus, Fujita Health University

Dr Saitoh is a board-certified physiatrist, Professor Emeritus of Fujita Health University, Senior advisor of Fujita Academy, Aichi, Japan. He also holds adjunct/visiting professorships at several universities, including Johns Hopkins University (USA), University of Health and Rehabilitation Sciences (China), China Medical University (China), and Kyoto Prefectural University of Medicine (Japan). He was selected as an international member of National Academy of Medicine (USA, 2020) and a recipient of China High-end Foreign Experts Program (China, 2015). He chaired the 13rd World Congress of International Society of Physical and Rehabilitation Medicine (ISPRM, Kobe, 2019) and chaired as the National representative, the 2nd World Dysphagia Summit (WDS, Nagoya, 2021). Recently he established the Asian Dysphagia Society as the chairperson (2023). His research areas are dysphagia, activity assistive technologies (including robotics, orthosis, smart home, activity monitoring, etc), motion analysis, locomotion, exercise science, and psychology.

Professor David Julian McClements

Distinguished Professor at the University of Massachusetts

David Julian McClements is a Distinguished Professor at the University of Massachusetts. He specializes in food biopolymers and colloids, with an emphasis on using structural design principles to improve the quality, safety, shelf-life, sustainability, and nutrition of foods. His recent research focusses on food nanotechnology, colloidal delivery systems, designing healthier processed foods, and creating next generation plant-based foods. He is the author of ten books, including “How to be a Successful Scientist” (2024). “Meat Less: The Next Food Revolution” (2023), “Food Nanotechnology” (2022), “Next Generation Plant-based Foods” (2022), and “Future Foods: How Modern Science is Transforming the Way We Eat” (2019). He has published over 1700 articles in scientific journals (>200,000 citations; H- index 213, Google Scholar, 2025) and secured over $20 million in external funding.

Wednesday, April 1

Professor Erik

van der Linden

Professor of Physics and Physical Chemistry of Foods, Wageningen University, The Netherlands

Erik van der Linden focusses on understanding the macroscopic scale in terms of the molecular and mesoscopic scale of, in particular for the last 25 years, food systems, during processing, storage, transport and/or consumption.

Mechanical properties, phase behavior and molecular assembly, play a dominant role in his work. The systems range from microemulsions, liquid crystals, high internal phase emulsions, emulsions, foams, powders, and gels. Systems may contain one or several different meso-structures, such as for example semi-flexible protein based fibrils, microcrystalline cellulose, and oil droplets.

More recently, the phase behavior of systems containing a large number of molecular components is being addressed, both experimentally and theoretically. This is an example of understanding more complex systems.

	The work in general requires the analyses on multiple spatial and temporal scales at the same time. For complex systems, AI tools may seem a promising approach, provided there is enough relevant data. To this end, a recent work introduced the encoding of Neural Networks (NN's) with physics to mitigate scarcity of data and the results suggest that encoding NN's with any disciplinary system based information yields promise to better predict properties of complex systems than NN's alone. Such encoding would also be scalable, allowing different properties to be combined, without repetitive training of the NN's. In the work, quantification of complexity is relevant. Such quantification has been relevant to interpret specific aspects of food sensory perception. Examples of product applications are an efficient gelating agent, temperature stable protein drinks for clinical nutrition, oiling off control of cheese, pasta containing 30% of vegetable, savory meringues, etc. An overall application area is the formulation of products with plant based ingredients. Before the appointment at Wageningen University, Erik van der Linden was a research scientist at Unilever research in the US and in The Netherlands, where he worked on detergents, rinse conditioners, and cosmetics. He conducted a postdoc research at Emory University and performed his PhD research on microemulsions at Leiden University, where he also had received his master degree in theoretical physics.
Professor Jianshe Chen **Head of the Division of Food and Sensory Science, Singapore Institute of Food and Biotechnology Innovation (SIFBI), A*STAR, Singapore**	Prof. Jianshe Chen is a Senior Principal Scientist at Singapore Institute of Food and Biotechnology Innovation (SIFBI), A*STAR, Singapore. During his research career, Prof. Chen has been exploring the oral behaviour of food during an eating process and the physical, oral physiological, and psychological principles behind eating and sensory perception. He is a pioneer in establishing food oral processing as a new emerging research area of food science and sensory science. He has published seven books and

over 250 research papers with an h-index 62 and an i10-index 183.

Prof. Chen is an elected fellow of the International Academy of Food Science and Technology (IAFoST), an honorary professor at Massey University, New Zealand, and a visiting professor at the University of Leeds, UK. He serves as the Editor-in- Chief of the Journal of Texture Studies, a Senior Editor of the Journal of Future Foods, and member of editorial board for a number of leading food science journals. Prof. Chen has been continuously ranked as the world top 2 % most influential scientists and among the top 100 most influential food scientists. He is also ranked by ScholarGPS as world's top 0.05 % researchers in the field of Agriculture and Natural Resources.

Thursday, April 2

Prof. Sylvie Turgeon

Université Laval, Canada

Sylvie L. Turgeon is professor in food science and co-director of the joint research unit GastronomiQc Lab. Dr Turgeon's main scientific interests aims to understand the molecular interactions in food to apprehend the functionality of proteins and polysaccharides. This knowledge should allow controlling the food structure which is the key to food product stability, organoleptic properties but also its nutritional properties. Her research interests include developing new approaches to food formulation using legume-based ingredients to increase the protein and fiber content of foods without producing by-products. Professor Turgeon shares her passion for food science by teaching undergraduate students and has supervised over 60 graduate students.

Professor Hidemitsu Furukawa

Yamagata University
https://swel.jp |
https://soft3d-c.jp

Prof. Hidemitsu Furukawa is a leading researcher in soft matter engineering and 4D printing. He is currently Distinguished Research Professor and Head of the Soft & Wet Matter Engineering Laboratory at Yamagata University, where he also serves as Special Adviser to the Executive Directors and Special Assistant to the Dean for Research. With a background in polymer physics, his research

spans gel materials, soft robotics, and sustainable digital manufacturing.

Prof. Furukawa leads several national R&D initiatives, including the Moonshot Agriculture Research Project, the NEDO Leading Research Program / Material & Bio Innovation, and the SIP (Strategic Innovation Promotion Program) Virtual Economy Project. He is also the founder and president of the Soft 3D Co-Creation Consortium, which promotes academic–industry collaboration in emerging technologies. His mission is to realize a sustainable future through co-creative, intelligent, and responsive soft material technologies.

Honorary Lecture

Wednesday, April 1

Professor Katsuyoshi Nishinari

Glyn O Phillips Hydrocolloids Research Centre, Department of Bioengineering and Food Science,
Hubei University of Technology.

Currently working as a specially appointed professor at Glyn O Phillips Hydrocolloids Research Centre, Department of Bioengineering and Food Science, Hubei University of Technology in China since 2013, and from 2024, as adjunct professor at Graphic Era deemed to be University in India. Graduated Dept Pure and Applied Sciences, Univ Tokyo in 1966. Then, Master thesis “Electric Birefringence of Polymer Solutions”, PhD thesis “Vibrational Properties of Viscoelastic Materials”. (Both from The University of Tokyo). Joined National Food Research Institute (Japan) in 1971. Visiting scientist at the Laboratory of Solid State Physics of Paul Sabatier University in Toulouse supported by French Government scholarship, and at the Laboratory of Biopolymer Physics of Riken (Physical and Chemical Institute) in Wako. He became a professor at School of Human Life Sciences of Osaka City University in 1992. An honorary member/consultant & an award from JSFST, JSR, JSMSHP, JSBR and IUFoST-Japan. Recipient of Food Hydrocolloids

	Trust Medal and One of Five Most Outstanding Contributors in Texture Research. Working in food hydrocolloids, rheology and their application to the dysphagia problems for 30 years. He wishes to activate the communication between food scientists, medical doctors, nurses, nutritionists, psychologists to improve the quality of life for persons with difficulty in mastication and deglutition to make a stronger network collaboration. He founded Japanese Society of Food Hydrocolloids to organize the 1st IHC in 1992. Google Scholar

Invited Speakers

Tuesday, March 31

Prof. Costas Nikiforidis **Associate Professor Biobased Soft Matter, Wageningen University, The Netherlands** 	Costas Nikiforidis's research focuses on understanding the properties and behaviour of biosourced proteins, lipids, and their interfaces across multiple length scales. By exploring how these natural components interact and organise, his work aims to design and develop functional, biologically inspired materials with applications in food, pharmaceuticals, and sustainable materials science
Dr. Tetsu Kamiya **Section Manager, Nagase & Co. Ltd., Tokyo, Japan**	Dr. Tetsu Kamiya is a researcher in food biomechanics and swallowing science, known for integrating experimental and computational methodologies to advance the understanding of mastication, bolus formation, and deglutition dynamics. He currently leads cross-disciplinary R&D initiatives at Nagase & Co., Ltd., and holds a Specially Appointed Professor position at Tohoku University, where he contributes to the development of next-generation evaluation technologies for food and biological systems. With dual doctoral degrees in engineering and agricultural science, Dr. Kamiya's work spans chewing simulation, swallowing bolus

flow analysis, and numerical swallowing modeling based on moving-particle simulation. He has developed novel experimental platforms—including a mastication simulator and a rheo-tribological swallowing analyzer—that quantify bolus behavior, organ–bolus interactions, and sensory-related physico-chemical changes. His numerical simulator, validated with medical imaging, provides mechanistic insights into bolus transport, force transmission to organs, and aspiration risk.Dr. Kamiya collaborates widely across academia, hospitals, and industry to bridge food engineering, oral physiology, and clinical dysphagia science. His mission is to contribute to safer and more comfortable eating environments—particularly for older individuals or those with swallowing difficulties—by establishing a unified scientific framework linking material properties, oral biomechanics, and human eating behavior.

Dr. Kentaro Matsumiya
Associate Professor

Kentaro Matsumiya is an Associate Professor in the Division of Food Science and Biotechnology at the Graduate School of Agriculture, Kyoto University, Japan. He received his Ph.D. from Kyoto University in 2014 with a dissertation titled "Destabilization of protein-based emulsions caused by bacteriostatic emulsifiers." From 2014 to 2015, he served as a Visiting Research Fellow at the School of Food Science and Nutrition, University of Leeds, UK. Currently, he is an Associate Editor for the Elsevier journal Food Structure.

His research focuses on food colloids and food structure, primarily in the context of their palatability. He has studied the processing and storage of foods derived from soybean, rice, wheat, milk, and eggs. In 2020, he received the Incentive Award from the Japanese Society for Food Science and Technology for his work on the use of edible microgels in food emulsions and foams.

Prof. Lester Geonzon

Lester Geonzon is currently an Assistant Professor at the Institute of Life and Environmental Sciences at the University of Tsukuba, Japan. He earned his

Institute of Life and Environmental Sciences, University of Tsukuba, Japan 	Ph.D. in Applied Marine Bioscience under the supervision of Prof. Shingo Matsukawa at the Tokyo University of Marine Science and Technology, Japan. Additionally, he has served as a JSPS Postdoctoral Fellow at the University of Tsukuba and an ISSP Fellow at the Institute for Solid State Physics at The University of Tokyo, Japan. His research focuses on elaborating the hierarchical structures and mechanical properties of biopolymer gels such as carrageenan and gelatin, employing rheological and microrheological analyses, light/Xray/Neutron scattering, and NMR techniques. Currently, his research interests are directed towards developing and designing innovative gel materials with controlled structures and mechanical characteristics by leveraging the multi-length scale analysis.
Prof. Aaron Goh Suk Meng **Associate Professor, Singapore Institute of Technology** 	Dr. Aaron Goh Suk Meng has been an Associate Professor at the Singapore Institute of Technology since 2014. He holds a B.Eng. and Ph.D. in Engineering from Imperial College London, UK. His research focuses on the mechanical and physical characterisation of soft materials, integrating engineering mechanics, food rheology, and finite element analysis to investigate food texture and biomechanical systems. Before joining SIT, he held academic and industrial research positions at Curtin University Sarawak, Malaysia, and Unilever R&D in the Netherlands. His research has been recognised with major awards, including the Royal Commission for the 1851 Exhibition Research Fellowship and the AACC International Rheology Division Young Scientist Award.
Wednesday, April 1	
Prof. Pedro Fardim **Professor at KU_Leuven, Belgium**	Professor @KU_Leuven, Belgium, committed to create sustainable technologies to support our planet and human health. D.Sc. Chemistry, State University of Campinas, UNICAMP, Brazil, Habilitation in Chemical Engineering, Åbo Akademi

University, Finland Director International Master Program In Chemical Engineering, KU Leuven

Member of KU Leuven Alumni Engineers Steering Board and KU Leuven Metaforum
President of EPNOE Association (www.epnoe.eu)
Editor of Clean Technologies and Environmental Policy (Springer Nature)
Editor of Journal of Polymer Engineering (De Gruyter)
Fellow of the Royal Society of Chemistry and the International Academy of Wood Science.
Expert for: European Science Foundation, European Commission, Swedish Knowledge Foundation, Research Council of Norway, Netherlands Organisation for Scientific Research, Nobel Committees for Physics and Chemistry, Swiss National Science Foundation, UK Natural Environment Research Council, The Finnish Research Impact Foundation, Academy of Finland, Latvian Council of Science, Christian Doppler Forschungsgesellschaft, Slovenian Research Agency, Inamori Foundation, American Chemical Society, 5 scientific journals, 6 International Scientific Conferences

Member of diplomatic delegations: 1) Finnish Prime Minister Matti Vanhanen, Brazil, May 2008 Official meeting with President of University of Sao Paulo; 2) Finnish Minister of Environment, Paula Lehtömäkki, China, November 2008, Official meeting with Minister of State Forestry Administration; 3) Finnish Prime Minister Jyrki Katainen, Brazil, February 2012, Official meetings with Brazilian Minister of Science and Technology (MCTI), Official meeting with President of Brazilian Development Bank (BNDES), Organization of Finnish-Brazilian Seminar in Bioeconomy in Sao Paulo; 4) Finnish Prime Minister Jyrki Katainen, Chile, February 2013, Official meetings with Chilean Minister of Education and Centre for Renewable Energy; 5) Finnish Minister of Education, Krista Kiuru, October 2013. Official meetings with Brazilian Minister of Education and Brazilian Minister of Science, Technology and Innovation, Organization of Finnish Brazilian Workshop in Biomass and

	Renewable Energy at FAPESP in Sao Paulo; 6) Finnish Minister of Environment, Ville Niinistö, April 2014, Official meetings with Brazilian Minister of Science, Technology and Innovation, Organization of Innovation Seminar at Brazilian Industry Federation (CNI) During 2005-2019 - Full Professor in Biomass Chemical Engineering, Head of the Laboratory of Fibre and Cellulose Technology, Åbo Akademi University, Finland During 2013-2014 - Distinguished Professor in Advanced Materials, Centre of Excellence for Advanced Materials Research (CEAMR), King Abdulaziz University -Jeddah, Saudi Arabia During 1993-2000 – R&D laboratory manager at Suzano, Brazil X: @Chemenghealth LinkedIn: https://www.linkedin.com/in/pedro-fardim-333272/ Web: www.pedrofardim.eu
Prof. Hyun Jin Park **Korea University** 	Professor Hyun Jin Park is a distinguished professor of Food Bioscience Department, Korea University since 2024. He is an adjunct Professor of Department of Packaging Science and Department of Agricultural and Biological Engineering, Clemson University since 1994. He works nanoscale science in food, functional food and food packaging – processing, application and regulation area. He started his professional career as a Research Associate/Assistant Professor in Department of Agricultural and Biological Engineering at the Clemson University, Clemson, SC, USA (1991-1993), and moved to Korea University in 1996 where he was later appointed as the Dean of the College of Life Sciences and Biotechnology (2019-2021). He had worked as the Outside Director of Lotte Confectionary Company (2010-2013) and the Technical Advisor of Samsung Fine Chemical (2019-2012). Recently, he received the Food Packaging Award in honor of Don Riester, Rees Davis, and Aaron Brody, Institute of Food Technologists (IFT) achievement Award, USA (2024), the Jinbo Order of

	Science and Technology from Korea Government in April 2020 and Daesang-KAST Food Award, Korea Academy of Science and Technology (KAST) in November 2020. He had worked as the 37th President, Korean Society of Food Science and Technology in 2017 and as the 11th President, Korean Society of Chitin and Chitosan during 2019-2021. He is a fellow of Koran Academy of Science and Technology (KAST) since 2014 and had served the Chairman, Division of Agriculture and Fisheries, KAST during 2022-2025. He was elected fellows of Institute of Food Technologists (IFT) in 2015 and International Academy of Food Science and Technology (IAFoST) of International Union of Food Science and Technology, in 2016. To date, he has published more than 350 SCI papers. He received the B.S. degree and M.S. degree from the department of the Food Engineering at the Korea University, Korea in 1983 and 1985, respectively. He received the Ph.D. degree from the department of Food Science and Technology at the University of Georgia, USA in 1991.
Prof. Stefan Kasapis **Professor, RMIT University, Melbourne, Australia** 	Stefan Kasapis is a Professor of Food Sciences at RMIT University. His research interests focus on bridging the gap that has emerged between advances in fundamental knowledge and direct application to product situations with a growing need for scientific input. His technological work secured in excess of thirteen million AUD in research grants and commercial contracts assisting the food industry to launch in the market novel formulations of liquid breakfast fortified with wholegrain oat and soy protein, oriental foods, high protein nutritional supplements for the elderly, alternative proteins and supporting the circular economy by repurposing food waste. He is recipient of the Food Group Junior Medal of the Royal Society of Chemistry for the best published work in Food Chemistry in the UK. Published in excess of 300 articles in learned journals in the field, edited 2 books and filed 9

	patents with the food industry. Served at the Editorial Boards of *Carbohydrate Polymers* and *BCDF* and he is currently Editor of *Food Hydrocolloids*, which is the leading research journal in food sciences according to impact factor (IF: 12.4). He was the Chairman of the 9th and 15th International Hydrocolloids Conference held in Singapore and Melbourne. He was awarded the inaugural Glyn O. Phillips Prize at the 16th International Hydrocolloids Conference held at the University of Guelph in October 2022. He is regularly invited to give Plenary Lectures around the world including the Universities of Guelph, Wageningen, Sydney, Melbourne and Massey. He features in the 2025 Stanford University ranking in the top 0.17% of scientists in the field of food sciences. Lifetime citation number of published work is 13,063 with the h-index being 62.
Prof. Jin-Kyu Rhee **Professor, Ewha Womans University, Seoul, South Korea** 	Jin-Kyu Rhee is a Professor in the Department of Food Science and Engineering at Ewha Womans University and the founder and CEO of the food-tech startup, SuFAB Inc. He is a pioneer in developing alternative meats (both plant-based and cultivated) using 3D food printing technology. His research focuses on the "Reverse-Engineering of Food Materials" and "Multi-Dimensional Spatial Re-Arrangement," concentrating on meticulously recreating the complex marbling, texture, and juiciness of real meat through 3D printing. Professor Rhee received his Ph.D. in Biotechnology from Yonsei University (2006). He was a postdoctoral researcher at The Scripps Research Institute in the USA (2007-2012) and a Senior Researcher at the Korea Basic Science Institute (KBSI) (2012-2015). Since joining Ewha Womans University in 2015, he has successfully bridged academic research with technology commercialization. His innovative research has been recognized with a CES 2025 Innovation Award for his 3D-printed steak

	technology, the Minister's Commendation from the Ministry of Agriculture, Food and Rural Affairs (MAFRA), and the National IT Industry Promotion Agency (NIPA) President's Award (2019). Furthermore, his research team was selected in 2024 to lead an 8.56 billion KRW national R&D project by the Ministry of Oceans and Fisheries (MOMAF) on "Cultured Seafood Production Technology," expanding his work beyond meat into the "Blue Food Tech" sector. Professor Rhee also plays key roles in the academic community, serving as a member of • the Korean Society of Food Science and Technology (KoSFoST), • the Korean Society for Microbiology and Biotechnology (KMB), • the Polymer Society of Korea, • the Korean Society of Food Preservation (KoSFoP), • the Korea Cell-Based Food Association. • and for the Sustainable Food Science and Technology Association (SFS), contributing to the advancement of the food-tech field.
Prof. Yong-Cheng Shi **Kansas State University (Manhattan, Kansas, USA)** 	Dr. Yong-Cheng Shi is a professor in the Department of Grain and Food Science at Kansas State University (Manhattan, Kansas, USA). He worked for National Starch Food Innovation (now Ingredion, Bridgewater, New Jersey, USA) from 1994 to 2005, developing resistant starch and modified starches for foods, emulsions, and encapsulations. His research areas include structure and function of cereal carbohydrates, physical, chemical, and enzymatic modifications of starches, flours, and other biopolymers, and developing technologies and products for food, beverage, delivery, nutrition, and pharmaceutical applications. He currently sits on the Editorial Board of Carbohydrate Polymers and the Advisory Board of Starch. Dr. Shi was the Belfort Lecturer at the Whistler Center for Carbohydrate Research, Purdue

University in 2015. He received Phil Williams Applied Research Award from AACC International (AACCI) (now Cereal & Grains Association) and was named AACCI Fellow in 2016. In 2021, he was awarded the Alsberg-French-Schoch Memorial Lectureship Award from the Cereals & Grains Association. In 2023, he received the Distinguished Graduate Faculty Award at Kansas State University.

Dr. Toshihiro Nakamori

Senior Research Strategy Leader at Fuji Oil Co., Ltd., Japan

Dr. Toshihiro Nakamori is a specialist in research, development, and strategic innovation of food ingredients. His work spans fundamental research, industrial product development, and long-term R&D planning, with a primary focus on soy proteins, bioactive peptides, and plant-derived hydrocolloids for food and life science applications.

He joined Fuji Oil in 1988 as a researcher in basic protein science, where he worked on improving the taste and functionality of soybean-derived peptides. He later led development programs on soy protein texture design and functional peptides, contributing to the commercialization of novel food and beverage products in collaboration with global manufacturers. His activities also extended to non-food applications, including plant oil–based cosmetic ingredients and polysaccharides.

A distinctive aspect of Dr. Nakamori's career is his engagement in interdisciplinary and translational research. He played a key role in the world's first successful complete farm-raising of eels in collaboration with the National Research Institute of Aquaculture, an achievement recognized with the 2004 Nikkei Bio Award.

Since 2013, he has held strategic leadership roles within Fuji Oil's R&D and innovation divisions, promoting industry–academia collaboration and advancing projects in functional foods, alternative proteins, and sustainable food systems. Dr. Nakamori received his Ph.D. from Kyushu

University, holds a Master's degree from Kitasato University, and is a licensed pharmacist.

Thursday, April 2

Prof. Sushil Dhital

Department of Chemical and Biological Engineering, Monash University

Assoc. Prof. Sushil Dhital (Department of Chemical and Biological Engineering, Monash University) is Editor of Carbohydrate Polymers and Past Chair of the Australasian Grain Science Association. He is internationally recognised for his work on starch, plant-based proteins, and innovative processing technologies, advancing food structure, nutrition, and sustainability.

Dr. Chaiwut Gamonpilas

National Metal and Materials Technology Center (MTEC), Thailand

Dr. Chaiwut Gamonpilas currently holds the position of Principal Researcher and leads the Food Materials Research Team at the National Metal and Materials Technology Center (MTEC), Thailand. He also serves as Adjunct Faculty in the Department of Food, Agriculture and Natural Resources, School of Environment, Resources and Development at the Asian Institute of Technology (AIT), Thailand.

His research focuses on food biopolymers, food structure design, oral processing, and digestion, with a strong emphasis on bridging fundamental science and practical applications. Dr. Gamonpilas has contributed extensively to advancing the understanding of food rheology, texture, and material science in food systems.

He is a member of the editorial boards of *Applied Food Research*, the *Journal of Texture Studies*, and

	the *Journal of Biorheology* (Japanese Society of Biorheology). His achievements have been recognised through several prestigious honours, including the WMRIF Young Materials Scientist Award and the National Research Award from the National Research Council of Thailand
Sobhan Savadkoohi **Hela Spice Australia, Food Innovation Center (FIC)** 	Dr. Sobhan Savadkoohi is a food scientist and technologist specialising in meat systems, plant-based structuring, and hydrocolloid functionality in complex food matrices. With an extensive background in meat science and sausage technology, his work bridges fundamental structure–function relationships with industrial-scale processing, particularly in high-moisture extrusion and texturised protein systems. Dr. Savadkoohi currently serves as Chief Technology Officer at HELA Spice Australia, where he leads innovation in clean-label ingredient systems, precision fermentation, and novel bio-based functional ingredients. His research and industrial projects focus on designing texture, water management, and functional performance in next-generation foods, including plant-based and hybrid protein products. He is actively involved in R&D commercialisation, ingredient system design, and global product development, working at the interface of science, processing, and consumer experience. His work contributes to advancing sustainable protein technologies and next-generation food structuring strategies.

Glyn O. Phillips Prize Recipients

The Glyn O. Phillips Prize is awarded biennially at the International Hydrocolloids Conferences (IHC) and consists of a cash prize and a medal. The prize was instituted to recognize the legacy of Prof. G. O. Phillips of Wrexham Glyndwr University, Wales, to the field of food hydrocolloids, polysaccharides and dietary fibre. Candidates should be mid-career scientists, academic or industrial, who are making excellent and sustained contributions to the field of food hydrocolloids (polysaccharides and/or proteins), including techno-functional or biofunctional aspects, and who are regular contributors to IHC conferences. Candidates must be nominated by a peer.

https://international-hydrocolloids-conference.com/phillips/index.html

2026

Prof. Qingbin Guo

Professor, Tianjin University of Science and Technology
2026 Glyn O. Phillips Prize Recipient

Dr. Qingbin Guo received his Ph.D. in Food Chemistry from the University of Guelph in 2013, followed by postdoctoral research at the University of Guelph, the Guelph Research and Development Centre (AAFC, Canada), and Kansas State University (USA). He also has been working as Professor in the Department of Food Science and Engineering at Tianjin University of Science and Technology (China).

Dr. Guo's research focuses on food hydrocolloids, dietary fibers, and bioactive carbohydrates, with particular emphasis on elucidating their structural-functional-bioactive relationships and valorizing agricultural by-products/processing side streams.

He has published more than 150 peer-reviewed papers and 9 books or book chapters with leading international journals. In 2024 and 2025, Dr. Guo was listed among Stanford/Elsevier's Top 2% of Scientists worldwide.

Dr. Guo serves as Associate Editor for *Bioactive Carbohydrates and Dietary Fibre*and as an Editorial

Board Member for *Food Hydrocolloids for Health*. He has chaired and organized multiple international hydrocolloid symposia/conferences and four special journal issues, contributing substantially to the advancement of polysaccharide science and sustainable food innovation.

Prof. Yapeng Fang

Distinguished Professor, Shanghai Jiao Tong University, China
2026 Glyn O. Phillips Prize Recipient

Dr. Yapeng Fang is currently a Distinguished Professor at the Department of Food Science and Technology, Shanghai Jiao Tong University. He is also a jointly appointed professor in the School of Health Science and Engineering, University of Shanghai for Science and Technology.

Dr. Fang received his Bachelor and Master degrees in Polymer Chemistry and Physics from Shanghai Jiao Tong University, and a PhD degree in Food Science and Health from Osaka City University.

He had a six-year working experience at Unilever Food and Health Research Institute, Netherlands, as a Marie-Curie Postdoc and at North East Wales Institute, UK, as a Reader. In 2011, Dr. Fang moved back to China and worked at Hubei University of Technology till 2018. Dr. Fang's research interest is focused on the applied basic research of food hydrocolloids, particularly those regarding the relationship between food structure, quality and nutrition. He coauthored over 280 papers in international peer-viewed journals and 60 patents, with more than 12000 citations. He also edited three books. He received the Natural Science Award of Hubei Province (a second-class prize) and the 2012 Young Scientist Excellence Award from IUFoST. He serves as an Associate Editor of the journals Food Hydrocolloids and the Founding Editor of the journal Food Biomacromolecules. Dr. Fang is supported by many different career schemes in China such as" Changjiang Distinguished Professorship', 'Ten Thousand Talent Program', 'NSFC Excellent Young Scholar' and 'New Century Excellent Talents in Universities'.

2024

Prof. Shaoping Nie

Professor and Vice President, Nanchang University, China.
2024 Glyn O. Phillips Prize Recipient

Prof. Shaoping Nie is distinguished professor of Nanchang University, and also Vice President of Nanchang University. He received his PhD degree in Food Science at Nanchang University in 2006. After that, he joined Nanchang University and promoted to Full Professor in 2011, he also worked as International Fellow at Temasek Polytechnic in Singapore for one year (2006-2007) and NSERC Visiting Fellow at Guelph Food Research Centre, Agriculture and Agri-Food Canada for two years (2009-2011).

He has been recognized as a leader in the national high-level talent special support program and his projects have been funded by the National Natural Science Foundation of China for Distinguished Young Scholars and Outstanding Young Scholars. Furthermore, Prof. Nie is the Associate Editor for Journal of Agricultural and Food Chemistry (2022.11-), Associate Editor of Bioactive Carbohydrates and Dietary Fibre (2016.1-2022.9), Founding Editor in Chief of Food Frontiers (2019.11-2022.12), also the editorial board member for Carbohydrate Polymers, Scientific Report, Food Science and Human Wellness, Current Topics in Nutraceutical Research.

Prof. Nie's research interests are focused on food chemistry and nutrition, food safety and analysis, especially on the structure, conformation and bioactivities of dietary fibre and bioactive polysaccharides and the relationship of their structure and bioactivities. He also focuses on the research in the field of precise regulation of food components and nutritional health, as well as the creation of new food products, and developing bioactive ingredients for the functional foods and nutraceutical products; developing novel dietary fibre and polysaccharides from natural agricultural products and explores their applications in foods, medicinal and pharmaceutical industries. Prof. Nie

has published more than 300 high-quality peer-reviewed scientific papers on journals such as Nature Communications as the first or corresponding authors (including co-authors). Additionally, he has edited 7 books and has been authorized 43 invention patents.

2022

Prof. Stefan Kasapis

Professor, RMIT University, Melbourne, Australia

The inaugural prize was awarded in 2022 to Prof. Stefan Kasapis of the Royal Melbourne Institute of Technology, Australia .

Stefan Kasapis is a Professor of Food Sciences at RMIT University. His research interests focus on bridging the gap that has emerged between advances in fundamental knowledge and direct application to product situations with a growing need for scientific input. His technological work secured in excess of thirteen million AUD in research grants and commercial contracts assisting the food industry to launch in the market novel formulations of liquid breakfast fortified with wholegrain oat and soy protein, oriental foods, high protein nutritional supplements for the elderly, alternative proteins and supporting the circular economy by repurposing food waste.

He is recipient of the Food Group Junior Medal of the Royal Society of Chemistry for the best published work in Food Chemistry in the UK. Published in excess of 300 articles in learned journals in the field, edited 2 books and filed 9 patents with the food industry. Served at the Editorial Boards of *Carbohydrate Polymers* and *BCDF* and he is currently Editor of *Food Hydrocolloids*, which is the leading research journal in food sciences according to impact factor (IF: 12.4). He was the Chairman of the 9th and 15th International Hydrocolloids Conference held in Singapore and Melbourne.

He was awarded the inaugural Glyn O. Phillips Prize at the 16th International Hydrocolloids Conference held at the University of Guelph in October 2022. He

	is regularly invited to give Plenary Lectures around the world including the Universities of Guelph, Wageningen, Sydney, Melbourne and Massey. He features in the 2025 Stanford University ranking in the top 0.17% of scientists in the field of food sciences. Lifetime citation number of published work is 13,063 with the h-index being 62.

18th International Hydrocolloids Conference, Mar. 30-April 2,

Tokyo University of Marine Science and Technology

Shinagawa Campus, Tokyo, Japan

Final Program as of March 23, 2026

(Colour Codes are explained at the end of the program, Page 35)

Monday, 30th March, 16:00 - 19:00, Drop-in Registration and Welcome Reception.

Tuesday 31st March

	Auditorium
8:40-9:00	**Opening**
9:00-9:40	**Plenary1 Eiichi Saitoh: The landscape of dysphagia management** abstract↗ Session Chair: Koichiro Matsuo
9:40-10:20	**Plenary2 David Julian McClements: Adventures in food hydrocolloids: A sci-fi journey through food** abstract↗ Session Chair: Yasuki Matsumura
10:20-10:40	**------ Coffee break -----**

	Room 1	Room 2	Room 3
10:40-11:10		**Keynote1 Koichiro Matsuo: Process Model of Feeding: Linking Oral Physiology, Bolus Properties, and Dysphagia Rehabilitation** abstract↗ Session Chair: Katsuyoshi Nishinari	**Keynote2 Costas Nikiforidis: Stimuli-responsive natural lipid droplets for selective lipid trafficking** abstract↗ Session Chair: Mitsutoshi Nakajima
	Session Chair: To be confirmed	Session Chair: To be confirmed	Session Chair: Costas Nikiforidis
11:10-11:30	Oral1 1033 Xi Yang: Gelation mechanism and network structure of gellan gum in low and high concentration of sucrose solutions abstract↗	Oral12 1099 H. Lozano Perez: Surface-Mediated Enzymatic Reactions of Banana Starches: Quantifying Amylase Interaction and Inhibition Effect abstract↗	Oral23 1002 Lingyun Chen: Preparation of size-controllable sustainable pulse protein microgels with high emulsifying performance abstract↗
11:30-11:50	Oral2 1085 Md Faruk Ahmed: Macadamia husk phenolic-loaded liposomes: In vitro digestibility and potential as yogurt-based delivery systems abstract↗	Oral13 1042 S. Elliott: Disentangling viscosity from non-catalytic binding in α-amylase inhibition abstract↗	Oral24 1220 S.S. Wong: Emulsifier-Free Stabilization of Low-Fat Whipped Cream via Clean-Label Starch–Hydrocolloid Network Engineering abstract↗
11:50-12:10	Oral3 1095 Aaron L. Pambu: Physicochemical and Functional Properties of Wet-Type Grinder–Treated Vegetables as Natural Hydrocolloids abstract↗	Oral14 Cancelled	Oral25 1202 Wahyu Ramadhan: High Internal Phase Emulsion of Sardine Oil Stabilized by Sodium Caseinate–Carrageenan Complexes: A Colloidal Approach to Omega-3 Enrichment in Freshwater Fish Surimi abstract↗
12:10-14:10	**---- LUNCH & Poster ----**		

14:10-14:40		**Keynote3 Tetsu Kamiya: Simulation of Chewing and Swallowing: Experimental and Numerical Approaches to Bolus Formation and Flow** abstract↗ Session Chair: Koichiro Matsuo	**Keynote4 Kentaro Matsumiya: Structuring Low-Smoke-Point MCTs for Aqueous Food Systems: Bulk Crystallization and Emulsification** abstract↗ Session Chair: Costas Nikiforidis
	Session Chair: Yoko Nitta	Session Chair: To be confirmed	Session Chair: Vassilis Kontogiorgos
14:40-15:00	Oral4 1015 José C. Bonilla: Advanced optics and image analysis for food hydrocolloid gel characterization abstract↗	Oral15 1071 Isao Kobayashi: Effect of adding thickened aqueous fluid to cooked, minced chicken breast meat on in vitro digestibility using human Gastric Digestion Simulator abstract↗	Oral26 1197 Ubonrat Siripatrawan: Cellulose-based foam-mat freeze-dried clove essential oil nanoemulsion as a natural food preservative abstract↗
15:00-15:20	Oral5 1005 V. P. Aparnna: Xanthan Gum–Driven Modulation of Physical Properties in Dairy Matrices for Enhanced 3D Food Printing abstract↗	Oral16 1189 Xinya Wang: Effect of pectin on calcium release from acid-induced pea protein gels during dynamic in vitro digestion abstract↗	Oral27 1167 Yanni Yang: Development of Emulsion-based Confectionery product: Understanding the Role of High Sugar Concentration in the Formation, Stability and Rheology of Emulsions abstract↗
15:20-15:40	Oral6 1143 Jacob K. Agbenorhevi: Evaluation of okra pectin as an alternative emulsifier in milk chocolate: Effects on rheological, textural and sensory properties abstract↗	Oral17 1066 Lingxin You: Impact of deep eutectic solvent–tailored nanocellulose on the stability and in vitro semi-dynamic digestion behavior of β-carotene conveying Pickering emulsions abstract↗	Oral28 1112 Lin Chen: High-yield and scalable preparation of lignin nanoparticles with uniform surface properties for stable Pickering emulsions abstract↗
15:40-16:00	Oral 7 1025 J. Cavallo: Maillard Reaction control in condensed biopolymer/co-solute model systems abstract↗	Oral18 1177 Haoxin Wang: Construction of a pH-driven self-assembled soy protein–lecithin microcage embedded in a κ-carrageenan hydrogel for weight-management abstract↗	Oral29 1192 Sangeun Park: Fish Gelatin/Chitosan Microfiber-Based 3D Porous Scaffolds Constructed with Pickering Emulsion and 3D Printing for Cell-Cultivated Meat abstract↗
16:00-16:20	**------ Coffee break -----**		

16:20-16:50	**Keynote5 Lester Geonzon: Linking Structure Across Multiple Scales to Macro-Properties in Hydrogels** abstract↗ Session Chair: Shingo Matsukawa	**Keynote6Aaron Goh Suk Meng: Hydrocolloids in Novel Foods for Dysphagia** abstract↗ Session Chair: Tetsu Kamiya	
	Session Chair: Lester Geonzon	Session Chair: Isao Kobayashi	Session Chair: To be confirmed
16:50-17:10	Oral8 1011 Chenghao Li: Structural and mechanical characterisation of microgels fabricated using spray gelation method abstract↗	Oral19 1159 Alan M. Smith: Evaluation of polysaccharides from Malvaceae as sustainable excipients for sustained-release oral tablets abstract↗	Oral30 1045 Mayang Gitta Pawitra: Designing Natural Co-Emulsifier Systems: Modified Porous Starch and Soy Lecithin for Egg-Yolk-Free Mayonnaise abstract↗
17:10-17:30	Oral9 1145 Zeenatu S. Adams: Influence of thermal processing on extraction efficiency and properties of tamarind xyloglucans abstract↗	Oral20 1007 Sanjida Humayun: Hybrid Carrageenans in Food and the Human Gut abstract↗	Oral31 1178 Nor Hayati Ibrahim: Functional properties of cold-set agar-based emulsion gel for fat replacer in fish sausages abstract↗
17:30-17:50	Oral10 1198 Narpinder Singh: Multimodal Fusion of Image, Textural and Colorimetric Features for Prediction of Bread Shelf-Life and Texture Decay abstract↗	Oral21 1115 Elena Vittadini: Acorn flour enriched bread: in vitro starch digestion and colonic fermentation abstract↗	Oral32 1003 Yinxuan Hu: Impact of various physical treatments on physicochemical and microstructural characteristics of vegetable oil-based whipped cream stabilised by faba bean protein abstract↗

17:50-18:10	Oral 11 1166 Florian Nettesheim: Evaluating Cohesiveness of Hydrocolloid Solutions Using Filament Stretching Extensional Rheometry (FiSER): Insights and Literature Comparison with CaBER abstract↗	Oral22 1050 Jingfeng Yang: Absorption of Enteromorpha prolifera Polysaccharides in Mice and the Protective Mechanism Against Alcohol-Induced Damage in L02 Cells abstract↗	Oral33 1219 Laxmikant S. Badwaik: Encapsulation to interface engineering of hydrocolloids for optimal nutrition design and functional food applications abstract↗
18:10	------ **Adjourn** -----		

Wednesday 1st April

	Auditorium
9:00-9:40	**Plenary3 Erik van der Linden: Physics ready to bite into complex soft matter** abstract↗ Session Chair: Steve Cui
9:40-10:20	**Plenary4 Jianshe Chen: Food oral processing: A colloidal perspective of eating and sensory perception** abstract↗ Session Chair: Katsuyoshi Nishinari
10:20-10:40	------ **Coffee break** -----

	Room 1	Room 2	Room 3
10:40-11:10		**Keynote7 Pedro Fardim: Pullulan-based gels for protein encapsulation and cell therapies** abstract↗ Session Chair: Dan Ramdath	**Keynote8 Hyun Jin Park: Nano-encapsulation technology of functional food ingredients using by 3-D printer for improving bioavailability** abstract↗ Session Chair: Mitsutoshi Nakajima
	Session Chair: To be confirmed	Session Chair: Pedro Fardim	Session Chair: Hyun Jin Park
11:10-11:30	Oral34 1004 Jack Yang: Predicting food hydrocolloids techno-functionality: more accurate data & smarter physics-based models abstract↗	Oral44 1136 Motoyoshi Kobayashi: Sol-gel like transition of semi-dilute suspension of rod-like cellulose nanoparticles abstract↗	Oral54 1022 Yonghui Li: Developing functionally enhanced pea proteins as innovative food ingredients abstract↗
11:30-11:50	Oral35 1200 M. Takemasa: Bigdata-driven approach for food texture analysis abstract↗	Oral45 1147 Shunsuke Sato: Optimum compositions for shear-induced gel formation in model colloid-polymer systems abstract↗	Oral55 1068 Syed Ubaid Ullah Shah: Enhancing Nutritional Value of Baked Products Using Fermented Lucerne (Medicago sativa) Flour as an Alternative Protein Source abstract↗
11:50-12:10	Oral36 1053 Erika Nozawa: Modeling and simulation of phase inversion processes going from fresh cream to butter via whipped cream by a complex systems approach with Coupled Map Lattice abstract↗	Oral46 1194 Lei Su: Ultrafast gelation of hyaluronan hydrogels via alternate compression-decompression abstract↗	Oral56 1034 Elle Ina Wilhelm: Protein dry spinning as a bottom-up approach for the design strategy of anisotropic structures in plant-based meat analogues abstract↗
12:10-13:40	**---- LUNCH & Poster ----**		
13:40-14:10	**Keynote9 Stefan Kasapis: Controlled delivery of bioactive compounds from natural polymers across the concentration range of industrial application** abstract↗ Session Chair: Motoyoshi Kobayashi		**Keynote10 Jin-Kyu Rhee: Multi-Dimensional Food Fabrication: A Bottom-Up Approach to Structuring Alternative and Cultivated Meats** abstract↗ Session Chair: Makoto Nakauma

	Session Chair: Lester Geonzon	Session Chair: Dan Ramdath	Session Chair: Jin-Kyu Rhee
14:10-14:30	Oral37 1049 Ubonrat Siripatrawan: Sustainable active packaging from chitosan infused with extract from pulsed electric field-treated microalgae to preserve quality of chicken fillet abstract↗	Oral47 1054 Ivan M. Lopez-Rodulfo: Polyphenols modulate faecal fermentation of dietary fibre depending on polysaccharide chemistry and supramolecular assembly abstract↗	Oral57 1055 MN Emmambux: Modified marama bean concentrate as an alternative to gluten protein abstract↗
14:30-14:50	Oral38 1044 Laura Roman: Fractionating cereal brans into functional polysaccharides through subcritical water extraction abstract↗	Oral48 1067 Loreto Muñoz: Advances in understanding the metabolic and hydrocolloidal relevance of fiber-rich fraction from chia seeds abstract↗	Oral58 1036 Aiqian Ye: The physical properties and microstructure of hybrid processed cheese formulated with plant protein ingredients and rennet casein abstract↗
14:50-15:10	Oral39 1117 D. Ghina Nadhifa: Textural engineering of analog rice using sago and fermented kidney bean flour hydrocolloids abstract↗	Oral49 1175 Thoithoi Tongbram: Short-soluble amylose chains inhibit long-term retrogradation and modulate in vitro digestion of waxy corn starch gels abstract↗	Oral59 1199 Maria Gräfenhahn: Enhancing structure formation in pea protein systems through sequential thermomechanical processing for sustainable meat alternatives abstract↗
15:10-15:30	Oral40 1181 Eui-Jung Han: Development of a Double-Network CaCO3-GDL Crosslinked Bioink for Cell-Compatible and Edible Scaffolds in Cultivated Fish abstract↗	Oral50 1191 Tantawan Pirak: Bioaccessibility of white mugwort (Artemisia lactiflora) polyphenol extract in the system with brown rice flour and inulin revealing by static in-vitro digestion model abstract↗	Oral60 1031 Lloyd Condict: Towards a Kinetic Understanding for Protein–Phenolic Interactions in the High Temperature Regime abstract↗
15:30-15:50	**------ Coffee break -----**		
15:50-16:20		**Keynote11 Yong-Cheng Shi: Modulating starch digestion: strategies for healthier starch-rich food development** abstract↗ Session Chair: Narpinder Singh	**Keynote12 Toshihiro Nakamori: Polysaccharide Gels and Soy Protein Gels: Molecular Origins of Hydration, Network Architecture, and Food Functionality** abstract↗

			Session Chair: Takao Nagano
	Session Chair: Koki Ryo	Session Chair: To be confirmed	Session Chair: Yasuki Matsumura
16:20-16:40	Oral41 1182 Seri Park: Development of 3D-Printable Marine-Derived Gels for Senior-Friendly Seafood Analogues abstract↗	Oral51 1082 Maria Franco: Influence of apple pomace to modulate the starch and polyphenol bioaccesibility of wheat bread co-formulated with pomace and soluble polysaccharides abstract↗	Oral61 1203 Marco Torre: Ultrasound-assisted extraction and colloidal properties of protein isolates from neglected Sicilian black chickpeas abstract↗
16:40-17:00	Oral42 1087 A. Rahmayanti Ramli: Wet-type grinder-treated rice bran as a natural hydrocolloid alternative for improving gluten-free rice bread quality abstract↗	Oral52 1131 Naushad M. Emmambux: Effects of Cowpea Protein Isolates and Stearic Acid on the Physio-chemical and In Vitro Starch Digestibility of High Amylose Maize Starch abstract↗	Oral62 1169 Naaman Francisco Nogueira Silva: Protein extraction of Pereskia aculeata leaves – effects of ultrasounds and Ohmic heating on their physical-chemical and acid gelling properties abstract↗
17:00-17:20	Oral43 1138 Anthony Halim: Effects of debranching and ultrasound treatment on starch nanoparticles fabrication: a structure-functional analysis abstract↗	Oral53 1103 G. Portillo-Perez: Effect of chao- and kosmotropic natural deep eutectic solvents on the chitin separation and from *h. Illucens* pupae molt shells abstract↗	Oral63 1186 Laua Roman: Protein Composition and Purity Modulates Structural Transitions of Sunflower and Lupin Proteins During Hydrothermal Processing abstract↗
17:20	------ **Adjourn** -----		
17:50-20:35	**Dinner, Katsuyoshi Nishinari Honorary Speaker (abstract↗), Next Conference Announcement, Poster Award**		

Thursday 2nd April

	Auditorium		
9:00-9:40	**Plenary5 Sylvie Turgeon: From purified hydrocolloids to complex ingredients: a sustainable alternative in food applications** abstract↗ Session Chair: Doug Goff		
9:40-10:20	**Plenary6 Hidemitsu Furukawa: From Underutilized Biomass to Digital Ingredients: Freeze- Milled Hydrocolloid Powders and Scalable 3D Food Printing** abstract↗ Session Chair: Shingo Matsukawa		
10:20-10:40	**------ Coffee break -----**		
	Room 1	**Room 2**	**Room 3**
10:40-11:10		**Keynote13 Sushil Dhital: Structure Matters: Tailoring Plant Proteins for Functional Food Applications** abstract↗ Session Chair: Isao Kobayashi	**Keynote14 Chaiwut Gamonpilas: Harnessing Mung Bean Proteins for Future Foods: Extraction, Modification, and Techno-functionality** abstract↗ Session Chair: Naushad Emmambux
	Session Chair: To be confirmed	Session Chair: Sushil Dhital	Session Chair: Chaiwut Gamonpilas

11:10-11:30	Oral64 1023 Xin Xu: Soft Lubrication of Model Absorbing Polysaccharide Solutions abstract↗	Oral72 Cancelled	Oral80 1012 Vassilis Kontogiorgos: Canola Proteins at the Air–Water Interface abstract↗
11:30-11:50	Oral65 1026 Wirasinee Supang: Effects of Drying Methods on Physicochemical and Functional Properties of Lemon Basil Seed Mucilage abstract↗	Oral73 1142 Mario M. Martinez: Selective detoxification of digesta revealed how apple pomace modulate transepithelial glucose transport and stimulate GLP-1 secretion abstract↗	Oral81 1157 Paraskevi Paximada: Exploration of electrospinning technique for producing food-grade nanofibers from legume protein concentrates and pullulan abstract↗
11:50-12:10	Oral66 1056 Nguyen N.D. Phan: Modulation of interfacial and foaming properties of cow milk under non-rancid lipolytic conditions abstract↗	Oral74 1076 Thaiza Serrano P. de Souza: Rheological, structural, and functional properties of β-glucan from barley and oat abstract↗	Oral82 1016 Belinda P. C. Dewi: From cow to bioreactor: physicochemical properties of native and precision fermentation-derived bovine β-casein for dairy analogue applications abstract↗
12:10-13:20	**---- LUNCH ----**		
13:20-13:50			**Keynote 15 S.Savadkoohi: Designing Texture in Plant-Based Foods: Protein–Hydrocolloid–Process Synergies** abstract↗ Session Chair: Kazuhiko Yamatoya
	Session Chair: Rando Tuvikene	Session Chair: To be confirmed	Session Chair: S. Savadkoohi

13:50-14:10	Oral67 1057 Tetsuo Torisu: Physicochemical properties of barley lipid transfer protein 1 contributing to beer foam quality abstract↗	Oral75 1059 Yael Vodovotz: Transforming Watermelon Rind and Pea Protein into a Functional Snack abstract↗	Oral83 1156 A. Raymundo: Bio-impact reformulation of "Caldo verde" soup with microalgae incorporation abstract↗
14:10-14:30	Oral68 1060 Yoko Nitta: Characterization of gel-forming components derived from mushrooms abstract↗	Oral761073 E. Smith: Investigating covalent interactions between 11S glycinin and genistein following thermal treatment abstract↗	Oral84 1183 Jin-Kyu Rhee: Tensile-Spun Gelatin-Chitosan Composite Scaffolds for Exploring Architecture-Cell Interaction Relationships abstract↗
14:30-14:50	Oral69 1171 SZ Razavi: Fermentation-assisted extraction and structural characterization of β-glucans from shiitake mushroom by-products abstract↗	Oral77 1164 Ali Ubeyitogullari: Enhancing the bioaccessibility of lutein and anthocyanins by loading into food-grade biopolymer gels using 3D food printing abstract↗	Oral85 1017 Belinda P. C. Dewi: Toward meltable plant-based cheese: mechanistic insights for product innovation abstract↗
14:50-15:05	**Short Break**		
15:05-15:25	Oral70 1092 Naoko Yuno-Ohta: Interactions of whey protein isolate and sodium caseinate with different kinds of mild preheating treatments abstract↗	Oral78 1029 Mario M. Martinez: Plant cell wall-polyphenol interactions modulate starch functionality, digestibility and the prebiotic outcomes of the tertiary system abstract↗	Oral86 1180 Shinbee Eun: Chlorella Polysaccharides as Compositional Modulators of Network Organization in Edible Fiber Scaffolds abstract↗
15:25-15:45	Oral71 1075 Federico Casanova: Role of globulins and albumins in oil-water interface properties of coconut meal proteins abstract↗	Oral79 1030 Ali Rashidinejad: Enhanced delivery and bitterness masking of appetite-suppressing hop bioactives using hydrocolloid microgels: A structure-function design for enhanced palatability, stability, and bioaccessibility abstract↗	Oral87 1150 Federico Casanova: Influence of ultrasound treatment on the emulsifying properties of Tenebrio molitor-based ingredients displaying different protein content abstract↗

15:45-16:10	**Closing**		
16:40-20:40	**Excursion**		

Colour Codes refer to the following program themes:

Innovative hydrocolloid design for delivering optimal nutrition and functional foods
Bioactive polysaccharides for human health
Physical properties of food hydrocolloids for enhanced product development
Role of hydrocolloids in pharmaceuticals and health/personal care products
Behavior of food biopolymers during digestion
Polysaccharide structures and their impact on gut microbiome
Functional hydrocolloids for plant-based dairy and meat alternatives.
Innovating with alternative proteins in new product development.

Hydrocolloids in emulsions and as emulsifiers

18th International Hydrocolloids Conference, Mar. 30-April 2, Tokyo University of Marine Science and Technology Shinagawa Campus, Tokyo, Japan

Abstracts for Invited Lectures

Plenary 1 The landscape of dysphagia management

Eiichi Saitoh, MD, DMSc[1*], Yoko Inamoto, SLP, PhD[2], Seiko Shibata, MD, DMSc3[3]

[1]Professor Emeritus and Senior Advisor, Fujita Health University, Aichi, Japan [2]Professor, Fujita Health University, Aichi, Japan [3]Associate Professor, Fujita Health University, Aichi, Japan [*]esaitoh1@me.com

The history of comprehensive dysphagia management (CDM) is relatively short. However, CDM—particularly from the perspective of rehabilitation medicine (RM)—has advanced rapidly in response to population aging. Moreover, CDM has now emerged as a prototype discipline that exemplifies activity medicine, the central concept of RM. The evolution of CDM has provided several important insights into the development of RM. In this lecture, we will:

1. Review the historical development of the CDM concept and explain how an activity-oriented perspective beyond organ-level pathology was established;
2. Present the view that eating is a core activity in ADL—an end in itself, rather than merely a means—and emphasize its distinction from the unique physiological integration of chewing and swallowing, which is not a mere sum of the two processes;
3. Discuss imaging-based evaluation not only as a tool for understanding pathophysiology but also as a means of guiding and justifying treatment strategies;
4. Examine the challenges arising from the oversimplified dichotomy of treatment versus compensation within RM, and discuss food modification as an environmental assist the eating as an activity; and
5. Highlight the international expansion of dysphagia management, with particular attention to Asia, where interest in CDM is currently the strongest

Return to program.

Plenary 2 Adventures in food hydrocolloids: A sci-fi journey through food

David Julian McClements

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Food hydrocolloids play a critical role in determining the quality, healthiness, sustainability, and shelf life of a diverse range of food and beverage products. Indeed, water-dispersible colloidal particles and polymers are the basic building blocks of many foods. In this oral presentation, I use my four decades of research in food hydrocolloids to demonstrate the importance and relevance of this subject, as well as to provide advice to young scientists embarking on a career in this exciting area. The presentation begins with research on developing ultrasonic spectroscopy methods to characterize the properties of food hydrocolloids, to understanding how hydrocolloids influence the stability and properties of emulsified foods, and how they can be used to develop novel delivery systems for bioactive components. Finally, the importance of food hydrocolloids in creating next-generation plant-based foods and healthier ultra-processed foods is highlighted.

Return to program.

Plenary 3 Physics ready to bite into complex soft matter.

Erik van der Linden[1*]

[1]*Wageningen University, The Netherlands*

Soft matter can be defined as matter that contains structures intermediate of the molecular and macroscopic scale, with energies of the order of the thermal energy. Complexity in such systems is enlarged by for example introducing multiple types of molecules, structures, and non-equilibrium phenomena, for example while considering living soft matter, or while processing, storing, and transporting such materials.
The applicability of physics will be first illustrated in a) understanding the gel strength of gelatin using a combination of critical scaling and a deflection length [1] , b) stability of a more complex system of protein fibrils, liquid crystalline cellulose fibers and emulsion droplets [2] , and c) formation of dense protein containing microgels and coacervates that lend themselves to realize high protein concentration heat stable liquids [3, 4] .
In engineering practically relevant structures, the use of a non-equilibrium pathways through a phase diagram (known as quenching) is useful [5, 6] . To this end, predicting equilibrium phase behaviour, preferably in practical multi- component systems, is

essential. We will present work on the phase behaviour of 2-component biopolymer mixtures [7-9] , in terms of experimentally accessible virial coefficients. We connect this to predictions of the phase diagram, and to extracting virial coefficients from literature data of phase diagrams [10] . Furthermore, we have extended the work towards the phase behaviour of multi- component (including, practical, polydisperse) mixtures by means of numerical, theoretical, and experimental work. Interestingly, part of the theoretical work is connected to a so called random matrix theory. This was originally used in predicting complex energy spectra in nuclear physics, following the initial works of Wigner [11] , [12] , a bit more recently to other quantum physics problems [13] , and, even more recently, to phase behaviour studies [14, 15] , with relevance to biological systems [16] .

In addressing properties of complex systems, a recent route using AI approaches was explored by us to encoding Neural Networks (NN's) with physics, to mitigate the general challenge of scarcity of data [17] . The results suggest that encoding NN's with any disciplinary system based information yields promise to better predict properties of complex systems than NN's alone. Such encoding would also be scalable, allowing different properties to be combined, without repetitive training of the NN's.

In the above, quantification of complexity is relevant. We address how such quantification has shown relevance to interpret specific aspects of food sensory perception and how it relates to a well know measure in information theory [18, 19] .

The work is hoped to provide ways to better predict the behaviour of complex soft matter, which in turn will enable to adapt more easily to using different ingredient sources, thus facilitating the use of more sustainable materials.

Reference:

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Plenary4 Food oral processing: A colloidal perspective of eating and sensory perception

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Eating and drinking is a highly complicated process, regulated primarily by the properties of food, oral physiological responses, neutral links, and more. During this

process, food (and beverages) undergoes constant changes in geometric structure, mechanical properties and even composition. This is demonstrated by the reduced particle size for solid and soft-solid food, varied rheological properties or deformability, and altered flow behaviour for liquid beverages. Also, during an eating process, saliva continues to secrete and interact with food and food components.

How these oral processes affect our sensory perception of food is critically relevant to food industry in designing healthy and tasty food. This presentation aims to reveal governing principles of food oral processing and sensory perception from a colloidal perspective, with a main focus on saliva foam and saliva emulsions. Oral-nasal mass transfer will also be examined in the form of molecule diffusion and aerosol particles. Effects of these oral phenomena on eating and sensory experience will be highlighted and discussed.

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Plenary 5 From purified hydrocolloids to complex ingredients: a sustainable alternative in food applications

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Proteins and polysaccharides ingredients are largely used in food formulations contributing through their well-known functional properties to food properties. However, there is a growing concern from consumer on the level of processing involved in food production as well as the environmental impact of the food offer. This is in this context that several years ago our team investigated the use of pulses as food ingredient. Pulses are used for more than 10000 years as a protein source. In Canada, they contributed to feeding indigenous peoples long before the arrival of Europeans. The cultivation of pulses enriches the soil naturally, has a lower impact than meat production and pulses offer an affordable source of protein, fibers and other nutrients. The functionality of more complex ingredients as purees will be presented using several pulses varieties (lentils, peas, etc). Characterization of these ingredients (microstructure, rheological, lubrication and textural properties) and of their interactions in systems of increasing complexity will allow to reveal their potential use as new

ingredients in emulsified, foamed and gelled food systems and the levers allowing to control their functionality. Purees can be produced industrially but also at smaller scale by a chef in restaurants and institutions (school, hospital, etc.). They offer a way to process pulses into an affordable new ingredient without any coproduct generation which is aligned with the desire to consume and introduce more plant-based foods in the population.

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Plenary 6

From Underutilized Biomass to Digital Ingredients: Freeze-Milled Hydrocolloid Powders and Scalable 3D Food Printing

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Hydrocolloids are central to food texture and stability, yet their societal impact can be amplified when we treat “materialization” itself as the innovation. This plenary lecture presents a practical pathway that connects hydrocolloid science to circular food systems by combining two forms of “mottainai”: unused cold energy and underutilized agri-marine resources.

Instead of modifying high-value foods merely to improve printability, we focus on upgrading materials that have struggled to gain value due to appearance, handling, or logistics constraints. Cryogenic milling enables powderization while mitigating quality loss, allowing diverse resources to be transformed into standardized, storable hydrocolloid-based ingredients. Once in powder form, materials become formulation- and shaping-ready: they can be blended, rehydrated, and structured as design targets rather than as “leftovers.”

I will discuss how this platform is implemented in practice: (i) feedstock design and rehydration control for robust extrusion-based shaping, (ii) texture creation through geometry and internal architecture—for example, patterned porous structures that tune broth uptake and flavor persistence— and (iii) scaling operations by parallelizing high-speed 3D food printers while completing dishes through a chef-in-the-loop workflow. I also introduce an approach to quantify texture beyond intuition using soft-material

response-based sensing, enabling systematic translation between rheology, geometry, and oral perception.

The talk closes with a simple framework—powderize, rehydrate, structure, evaluate—that helps researchers and practitioners turn hydrocolloids into a materialization platform for distributed, sustainable, and enjoyable food manufacturing.

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Keynote 1 Process Model of Feeding: Linking Oral Physiology, Bolus Properties, and Dysphagia Rehabilitation

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The process model of feeding provides an integrated framework for understanding how humans chew, manage, and swallow food through a continuous sequence of physiological events. Rather than viewing mastication and swallowing as separate functions, this model conceptualizes feeding as a coordinated process encompassing chewing, bolus formation, oropharyngeal transport, pharyngeal swallowing, and airway protection. It highlights how food properties interact with oral physiology to shape safe and efficient deglutition.
Central to this model is the temporal and spatial coordination of the jaw, tongue, hyoid, soft palate, and oropharyngeal structures. Mastication requires rhythmic jaw movements synchronized with dynamic tongue positioning to break the food into particles and form them as a bolus. During oropharyngeal transport, the tongue generates patterned pressure sequences while stabilizing against the palate, ensuring controlled propulsion toward the pharynx (so called stage II transport). This pre-swallow bolus transport and the timing of swallow initiation are significantly altered by food consistencies and gravity (body position).
The process model provides a robust foundation for the importance of mastication in dysphagia management. This presentation will connect oral physiology, bolus properties, and process-based understanding to advance clinical approaches for improving mastication and swallowing outcomes in clinical settings.

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Keynote 2 Stimuli-responsive natural lipid droplets for selective lipid trafficking

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Natural lipid droplets (LDs or oleosomes) play a crucial role in cellular function because they transport lipids across cell membranes. By combining experimental techniques with molecular dynamics simulations, we demonstrate the role of the LD membrane in lipid trafficking (absorption or release). Lipids can permeate the LD membrane via hydrophobic interactions and reside in its core, leading to LD volume expansion and a decrease in membrane density. Similarly, when LDs are in contact with a hydrophobic surface, lipids are fueled through a phospholipid channel, leading to LD deflation. The ability of the LDs to expand or shrink is attributed to the weak lateral molecular interactions in the membrane phospholipid monolayer, which sits on the liquid triacylglycerol core, allowing reversible dilation. The mechanistic understanding of lipid trafficking by LDs is advancing our understanding of LD functions, which can enable the delicate, targeted delivery of therapeutics for disease treatment.

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Keynote 3 Simulation of Chewing and Swallowing: Experimental and Numerical Approaches to Bolus Formation and Flow

Tetsu Kamiya

Nagase & Co. Ltd., Tokyo, Japan

Chewing and swallowing are complex biomechanical processes in which food transitions from fragmented solids to a cohesive bolus and is safely transported through the oropharynx. This keynote introduces a series of experimental and numerical simulation tools developed to quantitatively investigate these processes
First, I will present an experimental swallowing simulator designed to simplify anatomical structures and organ motions while capturing essential bolus behaviors. Using controlled surface conditions and optical measurements, this system quantifies bolus spreading, cohesion, and flow patterns on a pseudo-pharyngeal surface, providing insight into how rheology and lubrication influence safe deglutition.

Second, I will describe an experimental chewing simulator that mimics jaw motion and tongue-assisted mixing in a simplified mechanical form. This system enables multimodal measurement of bolus formation, including structural breakdown, torque and force profiles, and dynamic changes in flavor and aroma release during mastication.
Finally, I will introduce a numerical swallowing simulator based on validated moving-particle methods. By integrating realistic organ motion, geometry, food rheology, and interface behavior, this computational framework visualizes bolus dynamics, predicts force transmission to organs, and supports mechanistic understanding of swallowing safety and aspiration risk.
Together, these simulation approaches offer a unified platform for linking food properties, oral biomechanics, and bolus behavior, with applications in product design, dysphagia management, and fundamental research on human eating processes.

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Keynote 4 Structuring Low-Smoke-Point MCTs for Aqueous Food Systems: Bulk Crystallization and Emulsification

Kentaro Matsumiya

Graduate School of Agriculture, Kyoto University

Medium-chain triacylglycerols (MCTs) differ from long-chain triacylglycerols (LCTs) in metabolic behavior and physical properties, yet their use in food systems is constrained by low smoke point (~150 °C) and limited compatibility with aqueous phases. To expand MCT utilization in aqueous matrices, we first examined the excipient-free structuring of MCT-rich oils into water-compatible powders. Tricaprin and trilaurin mixed with medium- and long-chain triacylglycerols (MLCT) spontaneously crystallized into the β-form powder below the solidification temperature, forming micrometer-ordered stacked plate crystals (1). Steric effects from the MLCT hindered fat crystal network formation and promoted porous lamellar structures; the resulting tricaprin-based powders were readily wettable and formed pastes with water, providing a route to handle low-smoke-point MCTs in dispersed aqueous systems.

In addition, we investigated how MCTs behave in emulsification compared with LCTs under technologically relevant conditions. High-purity MCT emulsions were compared with LCT systems using model foods (creamers, dressings, mayonnaises) under refrigerated storage, freeze–thaw cycling, and heating. MCT emulsions demonstrated higher emulsifying activity and freeze–thaw stability and increased oil droplet

coalescence during heating (2). Creaming and oil-off were correlated with the magnitude of interfacial elasticity and its temperature responsiveness through analyses of interfacial tension, zeta potential, interfacial elasticity, and adsorbed protein characteristics (3). The two lines of work describe how bulk crystallization design and interfacial organization govern the coexistence of low-smoke-point MCTs with water, providing a physicochemical basis for structuring MCT-containing aqueous foods.

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Keynote 5 Linking Structure Across Multiple Scales to Macro-Properties in Hydrogels

Lester Geonzon

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Hydrogels play a central role in food systems by controlling texture, stability, and sensory attributes. These properties are largely governed by gel network architecture and gelation mechanisms. Among food-grade biopolymers, carrageenan is widely used due to its strong gel-forming ability and compatibility with diverse food formulations. In particular, κ- (KC) and ι-carrageenan (IC) exhibit distinctly different textural and rheological behaviors despite only subtle differences in molecular structure. In this presentation, the structure–texture relationships of KC, IC, and their mixtures were systematically investigated using a multi-length-scale approach. Small- and large-amplitude oscillatory shear measurements revealed contrasting viscoelastic responses, with KC forming stiff and brittle gels and IC producing softer, more deformable networks. These rheological differences were linked to aggregate formation and organization using small-angle neutron scattering (SANS) [1-2]. Pulsed NMR measurements further provided insight into molecular mobility, confirming the formation of rigid aggregates in KC gels and more flexible assemblies in IC systems. Furthermore,

mechanical properties were tuned through controlled chemical cross-linking and ion-induced bundling of double-helical structures. The synergistic action of monovalent and tetravalent cations significantly enhanced gel stiffness. In-situ SAXS/WAXS measurements under deformation revealed strain-induced structural ordering, leading to strain-stiffening behavior and improved mechanical durability [3]. These findings provide design principles for tailoring texture and mechanical performance of carrageenan-based hydrogels for food and advanced applications that necessitate strong mechanical characteristics.

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Keynote 6 Hydrocolloids in Novel Foods for Dysphagia

Aaron Goh Suk Meng

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Hydrocolloids play a crucial role in the development of texture-modified foods for individuals with dysphagia, with the dual aim of ensuring swallowing safety and enhancing eating enjoyment. By modulating viscosity, gelation, and structural stability, hydrocolloids provide a versatile toolbox for tailoring food textures to clinical requirements while maintaining sensory appeal. In pureed foods, for example, they enable reshaping into recognisable and visually appealing forms while also preventing phase separation of thin liquid from the bulk. An emerging application is their role in controlling structural breakdown within the category of transitional foods—products that transform texture during oral processing with little to no chewing. Using foamed gels as a model system, this presentation demonstrates how variations in internal structure influence fracture stress, oral processing time, and perceived textural transitions. These insights highlight the potential of hydrocolloids to expand the repertoire of safe, acceptable, and innovative foods for dysphagia management.

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Keynote 7 Pullulan-based gels for protein encapsulation and cell therapies

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Pullulan hydrogels offer an aqueous, cytocompatible platform whose network architecture can be tuned from the bioproduction stage, where mineral-salt/sugar-stress conditions modulate yield and molar-mass distribution, enabling control over diffusivity and release kinetics for labile proteins. Chemical/physical hybridization further broadens function: semi-interpenetrating pullulan–PVA networks ionically doped with NaCl achieve tensile strengths up to 2.72 MPa and ionic conductivities ≈10.4 S m^{-1}, supporting mechano-electrochemical readouts and stimulus-responsive delivery in bioelectronic or rehabilitation contexts. Within polysaccharide tissue-engineering frameworks, design rules linking backbone chemistry, crosslink density, and ligand display to cell viability have been articulated, while microgel-based carriers and microporous annealed networks enable rapid cell ingress for regenerative applications. In parallel, we investigate protein adsorption as a purification-oriented modality using bio-based mixed-mode beads. Composite formulations combining pullulan, alginate, agar, and guar gum were synthesized, characterized (FTIR; swelling), and screened with BSA as a model protein; performance-driven down-selection identified alginate–pullulan and alginate-only beads for mechanistic analysis (SEM, N_2-physisorption, TBO assay) and validation on a bioreactor-derived protein mixture. Integrating encapsulation and adsorption within one pullulan-centric toolbox enables protection, presentation, and purification of therapeutic proteins while furnishing cell-instructive microenvironments—advancing translational readiness for localized delivery and cell therapies.

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Keynote8 Nano-encapsulation technology of functional food ingredients using by 3-D printer for improving bioavailability

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Functional foods include all ranges of food compounds such as vitamins, mineral supplement, herbs, phytochemicals (e.g. polyphenols and carotenoids), and probiotics which are tied up with disease prevention and health promotion. Lipophilic functional foods have been great attention because of their diverse health benefits such as excellent nutritional value, antioxidant, anti-inflammatory, wound healing, and anti-cancer. Among various strategies, nano-carrier systems have been popularly developed worldwide for effective delivery of lipophilic nutraceuticals. When nano-carriers are applied in food system or oral delivery system, it should be considered that they must be stable in food formulations, non-toxic, biodegradable, and applicable to various foods processing system.

Enhancing the nutritional value of food and satisfying the consumer needs through diversification and personalization of food is a new trend in the food market. This trend encourages industrial and scientific organizations to develop new strategies to enhance bioactive constituents in processed foods. When hydrophobic substances are added to food, many problems emerge, such as temperature and pH sensitivity, a low bioavailability, and chemical degradation and proneness to oxidative. In addition, the biggest problem with hydrophobic substances is that they have low solubility and are not easy to add to food. Therefore, a new strategy is needed to use hydrophobic functional materials in food 3D printing technology, and for this, an emulsion-based delivery system was introduced.

Three-dimensional (3D) printing is an innovative material manufacturing technology that can be used to construct complex structures. Oral mucosal adhesive films (OMAFs) have attracted attention as delivery systems for the easy ingestion of functional substances. However, conventional casting-based production limits the potential for personalization and controllable onset of action of functional substances. Although inkjet-type substance impregnation technology has been developed, it remains challenging to control the release characteristics, and the loadable capacity is lacking. The custom OMAF system was developed using a three-dimensional (3D) printer and loaded with curcumin as a model functional substance. Hydroxypropyl methylcellulose was embedded as an OMAF matrix, and the curcumin core was loaded through 3D printing. The embedded curcumin reached defined doses of 34.53–138.13 ppm depending on the infill patterns and nozzle sizes. In addition, the mechanical properties of the OMAF were modified according to the direction of 3D printing. The 3D printing can provide customized dosages of functional substances as well as control dissolution and improve stability.

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Keynote 9 Controlled delivery of bioactive compounds from natural polymers across the concentration range of industrial application

Stefan Kasapis

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The diffusion of bioactive solutes in matrices of natural polymers has application in a wide range of fields including biomedicine, functional foods and nutraceuticals. In this respect, it is critical that the delivery of such bioactive agents is controlled via the ability of biopolymers to restrict the diffusive movement of a small molecule co-solute. It is therefore important to have an understanding of the parameters governing solute diffusion within polymeric systems as well as the means by which they affect diffusion. For this reason, a number of mathematical expressions based on theoretical concepts should be developed in an effort to model the solute diffusion in biopolymer systems hence affording a rapid screening and subsequent utilisation of a number of delivery vehicles for optimal application and control.
If the solute is homogeneously distributed within a material, which constitutes the release-rate controlling barrier, the device is called a “monolithic system”. In this case, we can focus on three common methods in administering bioactive compounds orally:

- Polymer based delivery systems with glassy consistency incorporating a molecularly dispersed bioactive compound
- Hydrogels made of crosslinked polymers with their three-dimensional structure being described as a mesh
- Pourable nutraceutical formulations with hydrocolloids as excipients being either dissolved or dispersed in a suitable aqueous solvent

Our results have demonstrated that the diffusion of bioactive compounds in high-solid systems with glassy consistency (typically solid levels above 70% w/w in formulations) can be quantified by an equation of fractional free volume. In here, the introduction of a coupling parameter reflects the extent to which the structural relaxation of the polymer is distinct from the molecular transport of the bioactive compound in the vicinity of the glass transition temperature [1,2].

Examination of the diffusion of bioactive compounds in low- to intermediate-solid gels (typically solid levels below 40% w/w in formulations) that are made of extensively crosslinked (i.e. enthalpic) networks as opposed to the lightly crosslinked (i.e. entropic) networks of glassy matrices can also be fruitful. This is achieved by a model that takes into consideration molecular interactions in the delivery device and the increased pathlength for diffusion due to size of the solute and network obstruction/tortuosity [3,4]. In the third case, a modified Stokes-Einstein equation was developed for interacting systems to provide an estimate of how binding interactions can impact diffusion by accounting for the association constant of a host – ligand complex in solution. Findings should be applied in liquid-like systems to develop a controlled delivery device that can modulate bioactive release based on the interaction strength and size of a host molecule [5,6].

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Keynote 10

Multi-Dimensional Food Fabrication: A Bottom-Up Approach to Structuring Alternative and Cultivated Meats

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To overcome the limitations of current alternative proteins in replicating the complex, hierarchical architecture of whole-cut meat, this presentation introduces "Multi-Dimensional Food Fabrication." This bottom-up approach synergizes biomaterials science, rheology, and advanced bioprinting to spatially rearrange reverse-engineered food microstructures using the proprietary *Foodructure* platform and *Rheome*r system.

For skeletal muscle emulation, solvent-free, tensile-spun gelatin-chitosan scaffolds were developed. By precisely tuning precursor rheology, optimal fiber alignment and mechanical resilience are achieved, directing robust myoblast adhesion and anisotropic myotube formation. Furthermore, for cultured seafood applications, transglutaminase-crosslinked Pickering emulgels provide porous scaffolds that enable essential volumetric cellular infiltration.

To accurately mimic the sensory experience of animal adipose tissue, advanced biphasic lipid structuring is employed. Oleogel-in-hydrogel bigels perfectly match the thermal melting profile of porcine fat at standard safe cooking temperatures. Additionally, double-network emulsion gels successfully replicate the gradual thermal collapse characteristic of bovine fat.

Crucially, the successful integration of these muscle and fat mimetics requires strict rheological control. By precisely calibrating printing parameters to the intrinsic gelation behaviors of the bio-inks, exceptional shape fidelity is ensured. Ultimately, this multi-dimensional strategy offers a scalable, scientifically rigorous pathway to creating sensorially authentic next-generation meat.

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Keynote 11 Modulating starch digestibility: strategies for healthier starch-rich food development

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Starch is a major component in cereal grains and a key source of dietary energy. Modulating starch digestibility is a critical strategy to develop healthier grain-based foods and mitigate the prevalence of chronic metabolic diseases such as obesity and type 2 diabetes. Approaches to shifting from rapidly digestible starch to slowly digestible starch and resistant starch to reduce glycemic impact and improve gut health include:

- Biological strategies: Developing crops with higher amylose content to naturally increase resistant starch,
- Processing-based strategies: Preserving or creating starch structures that resist enzymatic digestion,
- Formulation and ingredient strategies: Adding resistant starch products, creating protective networks around starch, or blocking digestive enzymes.

This presentation will highlight our research on utilizing dry roller-milling to produce pulse flours with high levels of intact cell walls that reduce starch digestibility and using high-amylose wheat flour to make healthier wheat-based food products.

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Keynote 12 Polysaccharide Gels and Soy Protein Gels Molecular Origins of Hydration, Network Architecture, and Food Functionality

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In food science, polysaccharide gels have been extensively studied and widely applied owing to their high hydration capacity and diverse gelation mechanisms. In parallel, protein-based gels, including soy protein gels, are gaining increasing importance in next-generation food systems, although their molecular design principles are often discussed separately from conventional hydrocolloid frameworks. This keynote compares polysaccharide gels and soy protein gels by focusing on fundamental differences in hydration behavior, gelation mechanisms, and underlying molecular architectures.
Polysaccharide gels typically form highly hydrated networks through ordered chain association, double-helix formation, and ionic crosslinking, resulting in soft, water-rich structures in which water is loosely bound within the network. In contrast, soy protein gels are formed through

partial denaturation induced by heat or pH shifts, followed by aggregation governed by hydrophobic interactions and disulfide bond formation. These processes generate relatively low-moisture yet mechanically robust gel networks, where water is more strongly confined at the molecular and mesoscopic levels.
This lecture discusses how such differences in molecular interactions and water confinement translate into macroscopic properties, including mechanical response, water-holding behavior, and structural stability. Particular emphasis is placed on the intrinsic compatibility of soy protein gels with lipids, a feature that clearly distinguishes protein gels from conventional polysaccharide hydrogels. Using the concept of emulsion-filled gels, the role of dispersed oil droplets as active structural elements and texture modulators is introduced as a versatile strategy for gel property design.
Finally, the potential of soy protein gels as low-moisture, lipid-compatible matrices is discussed in relation to meat analogs and other alternative protein foods. By positioning protein gels as a natural extension of hydrocolloid science rather than a competing paradigm, this keynote aims to broaden the conceptual framework of gel design toward sustainable, multifunctional, and future-oriented food structures.

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Keynote 13

Structure Matters: Tailoring Plant Proteins for Functional Food Application

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Plant protein functionality is governed by molecular architecture, compositional balance, and processing-induced structural transitions. Across diverse botanical sources—including pea, lentil, mungbean, lupin, faba bean, and wheat—variations in globulin composition (particularly legumin–vicilin ratio), secondary structure, solubility, and aggregation behaviour determine gelation, rheology, extrusion response, and final texture. Comparative structural analyses show that underutilised pulses such as mungbean and lentil retain native conformations and high solubility after extraction, in contrast to more denatured commercial isolates. Vicilin-rich systems exhibit lower critical protein concentration and gelation temperature, higher viscosity development, and stronger fibrous structures during high-moisture extrusion, while legumin-rich systems promote network reinforcement through reaggregation and macromolecular assembly. Processing history further modulates structure–function relationships. Hydration strategy, drying method, high-temperature treatment (95–120 °C), and extrusion govern molecular unfolding, β-sheet formation, aggregate size distribution, and extractability. Controlled structural transitions can enhance gel elasticity, viscosity stability, and anisotropic structure formation, whereas excessive aggregation leads to

weak or discontinuous networks. Importantly, insoluble fractions often retain ordered secondary structures and participate actively in network formation, challenging the assumption that they are functionally inert. Protein–starch interactions emerge as a critical design variable under thermal and high-shear conditions. Starch substitution stabilises high-temperature gel systems by modulating phase separation and reinforcing network continuity. Amylose–amylopectin balance, together with protein composition, dictates viscosity development, gel strength, and thermal resilience. High-amylose matrices alter protein secondary structure and water-binding behaviour, reshaping dough elasticity and resistance to deformation. Collectively, these findings establish a structure–gelation–processing paradigm for plant proteins. By integrating molecular composition, conformational state, and controlled processing, plant proteins can be rationally tailored for heat-stable gels, fibrous meat analogues, dough systems, and clean-label structured foods.

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Keynote 14 Harnessing Mung Bean Proteins for Future Foods: Extraction, Modification, and Techno-functionality

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Pulses are nutrient-dense crops containing 15–30% protein, positioning them as promising alternative protein sources to support sustainable food systems. Among these, mung bean (*Vigna radiata L.*), a staple pulse widely cultivated across Asia, offers high-quality globular proteins such as 8S vicilin and 11S legumin, making it a potential ingredient to complement or partially replace animal-derived proteins in diverse food applications. Despite this potential, mechanistic understanding of how extraction conditions influence protein structural, and the resulting techno-functional performance of mung bean proteins remains underexplored. This presentation provides a comprehensive assessment of mung bean protein extraction using two approaches: (i) a sequential fractionation strategy targeting differential solubility to recover enriched protein fractions, and (ii) a conventional industrially relevant alkaline extraction process. The talk highlights how extraction routes influence structural properties–including molecular weight distribution, secondary structure, surface hydrophobicity, free

sulfhydryl content–and relate these to their techno-functional properties relevant for plant-based food design, particularly gelation, emulsification, foaming, and interfacial stabilisation. The presentation further explores ultrasonication as a scalable physical modification method for tuning protein assembly and functionality. The presentation concludes by demonstrating the functional potential of mung bean proteins in next-generation plant-based food product design, spanning applications from meat analogues to high protein jelly drinks. These findings emphasise the strategic value of mung bean protein as a versatile functional ingredient and provide both fundamental knowledge and translation insights to support its integration into high-performance plant-based food formulations.

Keywords: Mung bean protein, Extraction, Ultrasonication, Techno-functionality, Future foods

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Keynote 15 Designing Texture in Plant-Based Foods: Protein–Hydrocolloid–Process Synergies

Sobhan Savadkoohi

Hela Spice Australia, Food Innovation Center (FIC)

The development of plant-based foods with desirable texture requires a systems-level understanding of the interplay between proteins, hydrocolloids, and processing conditions. While proteins provide the primary structural network, hydrocolloids act as modulators of hydration, phase behaviour, and network organisation, particularly under thermo-mechanical processing such as high-moisture extrusion.

This presentation explores how protein–hydrocolloid interactions evolve under shear, heat, and moisture gradients, leading to the formation of anisotropic, fibrous structures that define the sensory attributes of meat analogues. Emphasis is placed on competitive and cooperative hydration, phase separation, and water mobility, and how these phenomena can be tuned to achieve targeted textural outcomes such as chewiness, juiciness, and structural integrity.

Drawing on both fundamental research and industrial case studies, this talk demonstrates that texture is an emergent property of formulation and processing combined, and that rational design of plant-based foods requires integrating hydrocolloid science with process engineering.

Return to program.

Honourary Lecture

Whither food hydrocolloids

Katsuyoshi Nishinari[1*]

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Physiological and functional studies have been attracting more and more attention together with food processing functions, gelling, thickening, and emulsifying, since the launching of the journal *Food Hydrocolloids*. Since food hydrocolloids play important roles in food oral processing study developed from texture studies, thickening and gelling agents used in dysphagia therapy are studied extensively. Wet granular matter physics approach is expected to shed more light on the rheological properties of dynamically changing bolus during oral processing. In addition to physical characteristics, taste and odor affect the mastication and deglutition, but this aspect has not been sufficiently clarified. This study requires the integration of oral and brain physiology and psychology, and the collaboration between different disciplines should be more activated.

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18th International Hydrocolloids Conference, Mar. 30-April 2, Tokyo University of Marine Science and Technology Shinagawa Campus, Tokyo, Japan

Abstracts for Oral Presentations

1002 Preparation of size-controllable sustainable pulse protein microgels with high emulsifying performance

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Plant proteins offer sustainable and eco-friendly alternatives to animal proteins for various applications. This study aimed to develop pulse protein microgels from lentil and fava bean proteins by protein-polysaccharide segregative phase separation. By adjusting the protein to alginate volume ratio, the mean microgel sizes (D3,2) were controlled at 3, 7 and 15 μm for lentil protein and 3, 7 and 19 μm for fava protein. This fabrication method efficiently produced size-controlled microgels with low energy consumption. The emulsifying properties of lentil protein microgels were further explored. Compared to untreated protein-stabilized emulsions, which exhibited creaming after one day, the microgel-stabilized emulsions showed no creaming after 28 days. Microgels of different sizes stabilized emulsions through distinct mechanisms. Confocal laser scanning microscopy images illustrated that the smallest microgels at 3μm absorbed at the oil-water interface, forming Pickering emulsions and effectively stabilizing emulsions with 25% and 50% oil volume fraction with nearly no creaming after one month of storage. The larger microgels showed reduced emulsifying stability at 25% oil but similar stability at 50%. They dispersed in the continuous phase, contributing to emulsion stability through steric hindrance and a gelling effect. Moreover, emulsions prepared from lentil protein microgel at 25% oil exhibited enhanced viscosity

and texture compared to emulsions made with untreated lentil protein at 50% oil. This research provides a strategy to improve the emulsifying properties of plant proteins for their wide applications in food formulations to create stable and healthy low-fat food products.

Return to program.

[1003] Impact of various physical treatments on physicochemical and microstructural characteristics of vegetable oil-based whipped cream stabilised by faba bean protein isolate

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In this study, faba bean protein isolate (FPI) aggregates, prepared through various treatments including conventional heating (CH), ultrasonication (US), and thermosonication (TS), were used to formulate plant-based whipped creams. The objective is to develop a clean-label and dairy-free whipped cream using vegetable oil and plant proteins. The effects of these treatments on the characteristics of FPI aggregates and the oil-in-water (O/W) emulsions made from them, both before and after whipping, were evaluated. Among the different treatments, TS was the most effective at denaturing and unfolding FPI molecules, resulting in the formation of extended, strand-like aggregates with the highest surface hydrophobicity and solubility. These strand-like aggregates, potentially formed by disulfide bonds, were confirmed through sodium

dodecyl sulphate-polyacrylamide gel electrophoresis (SDS-PAGE). In contrast, untreated and CH-treated FPI samples formed large aggregates with low solubility and surface hydrophobicity. Moreover, emulsions stabilised by TS-treated FPI exhibited the smallest oil droplet size and the greatest mechanical strength, leading to superior whipping performance, with the highest overrun and lowest serum release. The strand-like aggregates formed by TS had a higher aspect ratio than the particle aggregates, facilitating better interfacial absorption, coverage, and the formation of a network structure. This enhanced the entrapment and stabilisation of air bubbles, contributing to improved whipping capability and stability. This study highlights TS-treated FPI as a promising ingredient for formulating plant-based whipped creams and aerated emulsions. Future research could explore other plant protein ingredients and improving organoleptic properties of plant-based whipped creams such as mimicking milk fat's melting behaviour.

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[1004] Predicting food hydrocolloids techno-functionality: more accurate data & smarter physics-based models

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Predicting techno-functional properties of food hydrocolloids, such as emulsification, foaming and gelling, remains a major challenge. While powerful models exist, they are only as good as the data they are trained on. Too often, data is of low quality and quantity, due to non-standardised, fragmented measurement methods and closed databases. These data-related challenges limit our ability to build accurate predictive tools for hydrocolloid functionality.

Therefore, we propose an approach that will advance techno-functionality prediction, which requires both better quality data and smarter models. On the data side, globally harmonised protocols and systematic reporting of data is essential to ensure comparability and reproducibility across laboratories in the whole food science

community. We will describe our recently started COST Action INFOTECH-DATA, which aims to connect the food colloids community by defining shared methodologies and build open-acceess databases.

On the modelling side, we aim to build models that can handle data scarcity. We present a hybrid modelling approach, which combines physics and machine learning, in so-called physics-encoded neural networks (PeNN) . We will showcase this approach for oil-in-water emulsions by predicting viscosity based on oil volume fraction and the type of protein used. We encode a neural network with a Quemada model, and compared this PeNN model with a standard neural network. The PeNN gave mean squared errors that was always (in a order of a factor thousand) smaller than a standard neural network. This means that we need a factor of 5-10 times less data to predict emulsion viscosity when encoding physics into a neural network. Encoding physics also adds causality to the model, reducing the black-box-nature of neural networks.

Together, better data and smarter model pave the way for predictive techno-functionality. This dual strategy will allow us to move into new scientific directions, and at the same time accelerate sustainable food structure design by enabling more rational ingredient & formulation choices.

Return to program.

[1005] Xanthan Gum–Driven Modulation of Physical Properties in Dairy Matrices for Enhanced 3D Food Printing

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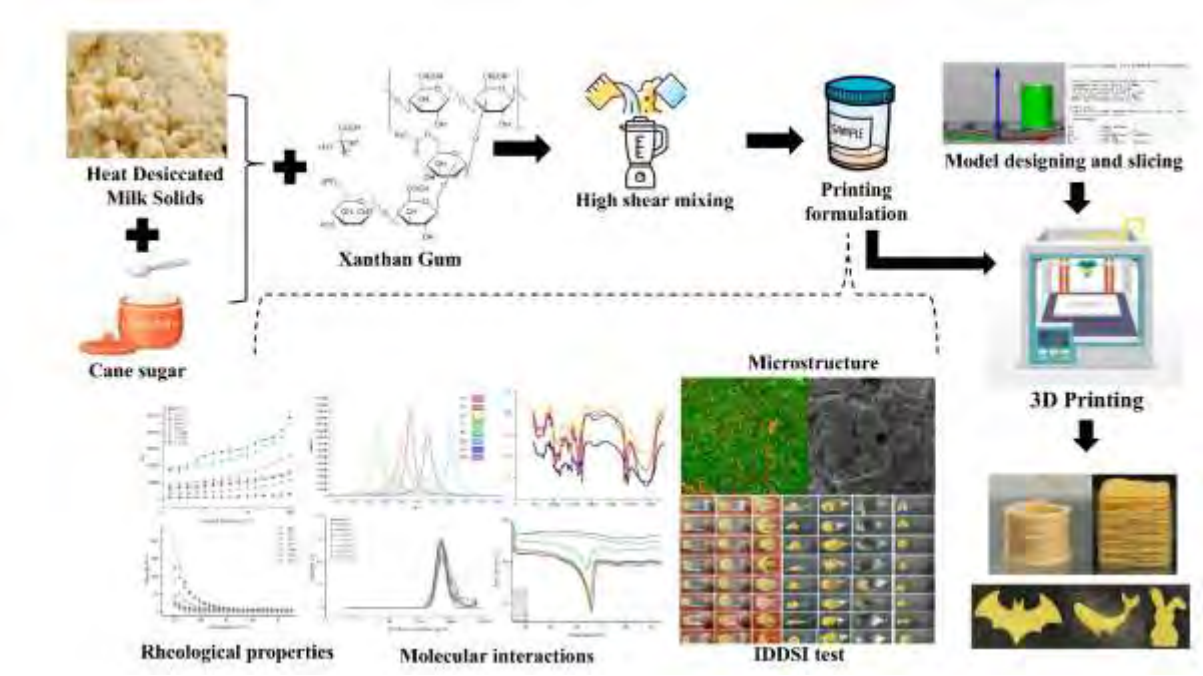
The ability of food hydrocolloids to engineer flow, structure, and lubrication makes them indispensable in next-generation food design. This study investigated the role of

xanthan gum (XG) in modulating the 3D printability, rheological behaviour, structural features, and attributes of formulations prepared from heat-desiccated milk solids (HDMS) added with cane sugar. XG was incorporated at 0.5, 1.0, and 1.5% (w/w) in HDMS with total solids (TS) of 55 and 60% and cane sugar concentrations of 20 and 30% and were examined for rheological, tribological, thermal, and microstructural characteristics in relation to 3D printing performance. XG addition significantly elevated viscosity, storage modulus (G′), yield stress, and shear recovery, collectively underpinning enhanced filament continuity and self-supporting capacity during extrusion. Thermal sweeps confirmed stability of these entangled networks under processing-relevant temperatures. Tribological measurements revealed reductions in friction coefficients across sliding regimes, suggesting improved oral lubrication and smoother bolus formation, attributes of direct relevance for dysphagia-oriented diets. At the molecular scale, FTIR spectra indicated a progressive α-helix to β-sheet transition within protein domains, while ^1H NMR revealed restricted water mobility arising from protein–hydrocolloid entanglement. Differential scanning calorimetry highlighted XG-induced glass transition depression and elevated ΔCp, consistent with water-binding and plasticization effects. Microstructural imaging (SEM, CLSM) corroborated these findings, showing denser, homogeneous protein–polysaccharide networks in XG-enriched formulations. Texture profile analysis further aligned with these structural modifications: increased hardness, cohesiveness, and chewiness were evident in gum-rich constructs, several of which satisfied International Dysphagia Diet Standardisation Initiative (IDDSI) Levels 5–7. Notably, the formulation comprising 60% HDMS, 20% sucrose, and 1% XG exhibited the most favourable balance of extrusion flowability, dimensional fidelity, and textural suitability. Collectively, these results demonstrate that deliberate modulation of hydrocolloid–protein interactions afford precise control over the physical properties that underpin printability, lubrication, and structural stability. By defining an optimal compositional window for XG, this work advances a framework for exploiting hydrocolloids as design tools in extrusion-based 3D printing of dairy products. Beyond immediate applications in dysphagia-friendly foods, the findings underscore the broader potential of hydrocolloid-mediated structuring to accelerate the development of customizable, nutritious, and consumer-oriented 3D printed food products.



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[1007] Hybrid Carrageenans in Food and the Human Gut

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Carrageenan functions as a hydrocolloid with remarkable gelling, thickening, and stabilizing properties, making it indispensable in diverse food formulations. It is widely utilized in dairy, confectionery, and processed meat products to improve viscosity, texture, and structural stability. Owing to its strong water-binding capacity and synergistic interactions with proteins, carrageenan plays a vital role in developing low-fat and plant-based food systems.

A hybrid sulfated galactan composed of κ- and β-carrageenan motifs was isolated from *Betaphycus gelatinus* through hot (95 °C) alkaline extraction, followed by alkali treatment to convert residual precursor molecules into the predominant carrageenan form. Both native and alkali-modified *Betaphycus* galactans were characterized by high-performance size-exclusion chromatography (HPSEC), high-performance ion-exclusion chromatography (HPIEC), high-performance anion-exchange chromatography (HPAEC), FTIR, and NMR spectroscopy to elucidate their molecular weight distribution and structural architecture.

Enzymatic depolymerization using κ-carrageenase revealed distinct distributions of κ- and β-carrabiose units. The enzyme-resistant fraction was enriched in β-carrageenans, whereas the enzyme-sensitive portion contained abundant oligo-κ- or κ/β-carrageenans, indicating a blockwise arrangement of κ- and β-domains within the *B. gelatinus* polymer. The effects of alkali treatment and counterions (K^+, Ca^{2+}, and Ba^{2+}) on the thermo-rheological properties of the hybrid galactan gels were evaluated by dynamic rheometry. K^+ ions markedly enhanced gelation, demonstrating their specific role in network stabilization. Strong interactions between the hybrid carrageenan and casein were also observed, as evidenced by rheological analysis, X-ray diffraction, and differential scanning calorimetry (DSC), confirming its high binding affinity and compatibility with dairy proteins.

Caco-2 cell assays showed no cytotoxic effects upon treatment with the hybrid carrageenan. The gene and protein expression of tight junction markers (Claudin-1, Occludin, and ZO-1) remained comparable to control cells, confirming preservation of epithelial barrier integrity during polymer exposure. Furthermore, the hybrid carrageenan inhibited the adhesion of intestinal pathogenic bacteria.

In vivo administration of the hybrid carrageenan in mice showed no observable toxicity, confirming its safety for potential food applications. Overall, this study underscores the superior gel-forming capacity of *Betaphycus* polymers—particularly in the presence of K^+ ions—their strong affinity toward milk proteins, and their favorable safety profile, supporting their potential use in functional and protein-enriched food formulations.

Return to program.

[1011] Structural and mechanical characterisation of microgels fabricated using spray gelation method

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Microgels are crosslinked polymer colloids with unique internal networks, exhibiting distinctive mechanical behaviors that are strongly governed by their nanoscale structure. However, establishing direct correlations between nanoscale organization and macroscopic mechanical properties remains challenging. This study aimed to characterise the structural and mechanical properties of pectin microgels using novel techniques to bridge the gap between their internal configuration and functional mechanics.

In the first study, a spray-gelation method was developed to efficiently fabricate pectin microgels with reproducible properties. Microgels were produced from low-methoxyl (LMP) and amidated low-methoxyl pectin (A-LMP), crosslinked with calcium ions at three concentrations (40, 80, and 200 mM) under acidic (pH 2.0) and neutral (pH 7.0) conditions. The resulting microgels were systematically characterized for yield, density, particle size, morphology, and surface features. Higher calcium concentrations and pH produced smaller, more uniform particles due to accelerated gelation. Unexpectedly, all pectin microgels were found to be non-interfacially active, in contrast to previous studies. Overall, the spray-gelation method offers a robust platform for the reproducible fabrication of pectin microgels and can be extended to other ionic polysaccharides.

In the second study, the internal structure and mechanical properties of these microgels were investigated to establish links between nanoscale configuration and functional mechanics. Transmission electron microscopy (TEM) of resin-embedded particles revealed that LMP microgels prepared at higher calcium concentrations and neutral pH exhibited more compact and uniform network structures due to enhanced junction-zone formation, whereas amidated pectin aggregated clusters that disrupted network linearity.

Single-particle mechanical measurements using a cantilevered-capillary force apparatus (CCFA) further established clear correlations between network architecture, microgel elasticity, and deformability.

Together, these findings provide new insights into the interplay between microgel internal structure and mechanics, offering valuable design principles for developing next-generation biopolymeric microgels with tailored functionality for applications in food systems, drug delivery, and stimuli-responsive soft materials.

Return to program.

[1012] Canola Proteins at the Air−Water Interface

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This study investigated the interfacial behaviour and viscoelastic properties of proteins at air-water interfaces in the presence or absence of salt. Pendant drop tensiometry, kinetic modelling, compression isotherms, Brewster angle microscopy (BAM), and dilatational rheology have been employed. Salt accelerates protein adsorption at the air-water interface, but it does not affect diffusion or rearrangement kinetics. The construction of compression isotherms revealed the formation of irreversible 2D networks, and BAM imaging showed microstructural faults. The elasticity and irreversibility of these films were confirmed using dilatational rheology, where the elastic modulus remained frequency-independent throughout the experimental window. Protein films were largely unaltered by salt in the linear viscoelastic range of the interface. However, notable effects were observed outside the linear viscoelastic range, where salt influenced mechanical responses, leading to strain-hardened interfaces. This study links the structural characteristics of canola protein to its functionalities, suggesting improvements in interfacial properties for sustainable foods.

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[1015] Advanced optics and image analysis for food hydrocolloid gel characterization

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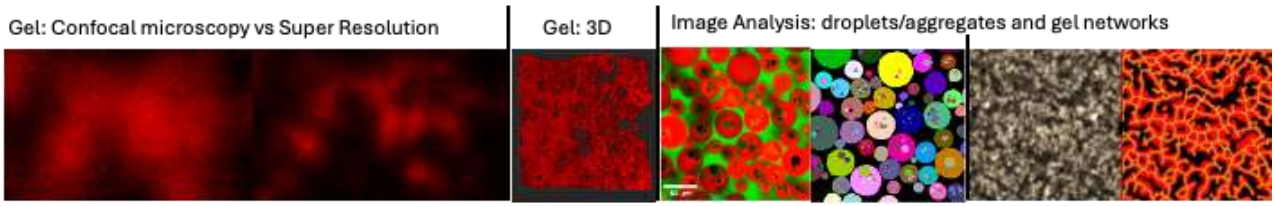
The development of new sustainable foods is currently hindered by their limited textural attributes. When processed, most sustainable food ingredients do not form structures similar to conventional food ingredients, often resulting in deficient textural attributes. This occurs at the microscopic scale, where food molecules form microscopic aggregates. These microstructures are then responsible for the macroscopic structural properties of the food materials. Therefore, studying how food molecules form microstructures will help us achieve a deeper understanding of food materials, especially of novel and sustainable foods. In this talk, I will delve into how to study food structures at the microscopic scale with the use of advanced optical microscopy techniques and quantitative image analysis.

The examples presented will be focused on the studies of food protein-based hydrocolloid gels, including traditional food ingredients as well as more sustainable food ingredients which have been studied under advanced microscopy techniques, including super-resolution optical microscopy, and label-free Coherent Raman spectroscopy-microscopy, among others. Examples also include microscopic videos of protein gelling. The microscopic images are processed and quantified using machine learning-based image analysis techniques. These quantitative microstructural parameters are then correlated to macroscopic rheological parameters, giving a multiscale understanding of food structures.

The results will show how these studies are deepening our understanding of food hydrocolloid gels, and food structure and texture in both animal and plant-based foods,

and how a deeper understanding of these structures will help us develop the rationally designed foods of the future. The use of advanced optical techniques is helping us arrive at a deeper understanding of aggregated protein structures and therefore, helping us understand how food molecules form microscopic structures that govern food texture.



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[1016] From cow to bioreactor: physicochemical properties of native and precision fermentation-derived bovine β-casein for dairy analogue applications

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Recombinant proteins, obtained through precision fermentation, present promising opportunities as novel ingredients for food applications. However, research into characterising their food-relevant functional properties is limited. The present study

investigated the physicochemical properties of recombinant bovine β-casein and compared these properties to those of their native bovine counterpart. Both were characterised in terms of solubility, zeta potential, calcium sensitivity, particle size distribution, radius of gyration, secondary structure, and rheological properties. When dissolved in a 50 mM sodium phosphate buffer, recombinant β-casein had a lower zeta potential over a different range of observed pHs. Its isoelectric point (pI) was shifted to a higher pH of 5.5 compared to 4.5 for native β-casein. Solubility trends generally matched the zeta potential profiles, with the most pronounced difference observed at pH 5.5, where recombinant β-casein showed lower solubility (33.02 ± 0.03 %) compared to native β-casein (78.45 ± 1.22 %). Secondary structures, determined using circular dichroism (CD) and small-angle X-ray scattering (SAXS) measurements, showed similar conformations and radii of gyration for both proteins. Recombinant β-casein demonstrated lower calcium sensitivity and formed stronger self-supporting gels with an earlier onset of acid-induced gelation compared to native β-casein. To further assess its application potential, a cheese model system was developed, demonstrating that recombinant β-casein can form stable, self-supporting gels with desirable texture properties comparable to those of native casein. These results provide the first comprehensive characterisation of the functional properties of recombinant β-casein in food-relevant conditions and highlight its potential use in developing next-generation dairy analogues developed through precision-fermented ingredients.

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[1017] Toward meltable plant-based cheese: mechanistic insights for product innovation

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Although consumer demand for plant-based cheese alternatives is increasing over the years, their market share remains limited due to poor meltability and texture performance compared to dairy cheeses. In this study, we investigated how compositional and structural differences between dairy and plant-based cheeses govern their thermal and rheological behaviour, with the goal of informing future product innovation. By combining temperature-dependent rheology and temperature-modulated differential scanning calorimetry (TMDSC), we demonstrate that these complementary techniques can effectively differentiate true melting from softening, revealing fundamental differences in structure–function relationships across cheese matrices.

We systematically compared commercially available dairy cheeses and plant-based cheese alternatives across a range of formats, including different ripening stages, processed cheeses, and plant-based products in block and grated forms. Viscoelastic and structural responses were assessed using small- and large-amplitude oscillatory shear (SAOS and LAOS) measurements, supported by confocal and polarised light microscopy. Thermal behaviour was evaluated using TMDSC to determine the freezable water content and the thermal transitions upon heating. This analysis separated reversing and non-reversing heat flows, a new method in the context of this research. Additionally, meltability (modified Schreiber test), water-holding capacity, and oil release were measured. This multimodal methodology enabled direct linkage of composition and matrix organisation to texture and melting behaviour, providing mechanistic insight into performance differences between dairy and plant-based cheese matrices.

Plant-based samples were found to be primarily starch–tropical plant fat matrices, with minor amounts of protein, while dairy samples consisted of protein-stabilised emulsion-filled gels. Temperature-dependent rheology separated the products into four distinct groups, classified based on the reversibility of changes in the moduli and the occurrence of true melting as opposed to simple softening. To our knowledge, this is the first systematic classification of meltability behaviour in these matrices. The four groups were defined as: (1) softening without reformation, (2) softening with reformation, (3) melting, and (4) collapse. True melting below 95 °C was observed predominantly in dairy cheeses and in only one plant-based block product, characterised by a sharp decrease in storage modulus (G′) and a clear G′–G″ crossover. In contrast, most plant-based cheeses exhibited a gradual reduction in G′ without crossover, consistent with progressive softening rather than network disintegration. The corresponding thermal transitions, as observed by TMDSC, were dominated by the non-reversing component of the heat flow, suggesting that the thermal behaviour of these cheeses was primarily governed by irreversible structural rearrangements rather than reversible melting processes. Together, the complementary rheological and TMDSC analyses demonstrate that visual melting does not necessarily correspond to true rheological melting,

providing mechanistic insights into the distinct structural dynamics of dairy and plant-based cheese matrices.

Furthermore, the confocal scanning laser microscope (CLSM) showed all samples to be emulsion-filled hydrogels, protein networks in dairy cheeses versus starch matrices in plant-based alternatives. Variations in fat globule size and distribution, however, did not explain fat release. By systematically linking composition, microstructure, rheology and thermal transitions, we provide a detailed account of the techno-functional properties that still need to be improved to better match consumer experience.

Return to program.

[1022] Developing functionally enhanced pea proteins as innovative food ingredients

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Pea protein is receiving significant interest as a sustainable plant-based protein source; however, its application in food systems remains limited by suboptimal functionality. This study aimed to enhance the techno-functional properties of pea protein through neoglycosylation with guar gum or gum arabic and enzymatic modification using transglutaminase or protein glutaminase. The physicochemical characteristics of the modified proteins were evaluated, along with their performance in mayonnaise-like dressings as egg replacers and in beef patties as functional extenders. Transglutaminase-crosslinked pea proteins demonstrated significantly enhanced water-holding capacity (5.2–5.6 g/g protein) relative to the control isolate (2.8 g/g). Guar gum–conjugated proteins exhibited exceptional emulsifying capacity and stability (up to ~100%), compared with the control protein (58% and 48%, respectively). Sequential modification (e.g., transglutaminase crosslinking followed by guar gum conjugation) produced synergistic improvements across multiple functionalities, including water and

oil holding, gelation, and emulsification, without compromising descriptive sensory attributes. In beef patties, incorporation of 2.5–5% sequentially modified pea protein improved fat and water retention, cooking yield, and texture tenderness. In mayonnaise-like emulsion gel dressings, guar gum–conjugated proteins significantly increased stability, apparent viscosity, and viscoelasticity while reducing droplet size; dressings formulated with 6–8% modified protein displayed markedly enhanced emulsification performance. In conclusion, our research demonstrates a combined enzymatic and neoglycosylation strategy to generate multifunctional pea protein ingredients with enhanced applicability in clean-label, plant-forward food systems.

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[1023] Soft Lubrication of Model Absorbing Polysaccharide Solutions

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Lubrication at the contact between soft substrates is central to determining the sensory perception of foods and the performance of personal care products. Many food systems are modeled as aqueous hydrocolloid solutions such as polymers or polysaccharides, in that their soft lubrication behaviour is influenced not only by the viscosity of the bulk solution but also their adsorbing properties. Here, we systematically modified the structure of glycol chitosan (GC) by grafting with poly(2-(methylsulfinyl)ethyl acrylate)

(PMSEA) of different molecular weights to form brush-like side chains, so that the different side chain lengths achieve an incremental change in the adsorption to the PDMS substrate. Polydopamine (PDA) was integrated into the GC-PMSEA to facilitate strong adsorption. While the systems of strongly-absorbing polymers show generally low friction across the range of speeds tested, the solutions of less absorbing polymer only demonstrate a reduction in friction at relatively high speeds and retain the behaviour of water-like fluids (distinct transition between boundary and mixed lubrication regimes, see Figure 1). This suggests that, in the fluid entrainment to the interfacial contact, the hydrodynamic condition (high shear rate) promotes the adsorption for the non- or weakly adsorbing polymers and increases viscosity in the localised area [1-2], making the transition to mixed lubrication occur at a lower speed. This investigation provides a mechanistic insight into the mutual interaction between soft lubrication systems and the adsorbing properties of polymers. The findings provide a framework for characterising the soft lubrication of hydrocolloids with applications to foods and synthetic bio-lubricants.

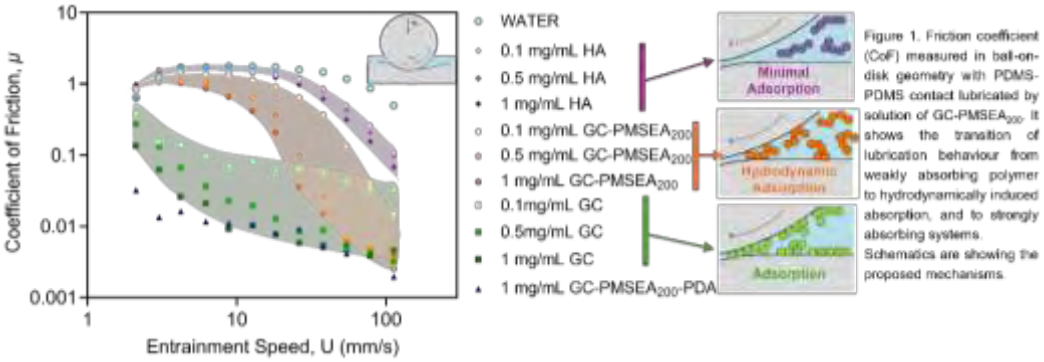

Figure 1. Friction coefficient (CoF) measured in ball-on-disk geometry with PDMS-PDMS contact lubricated by solution of GC-PMSEA$_{200}$. It shows the transition of lubrication behaviour from weakly absorbing polymer to hydrodynamically induced absorption, and to strongly absorbing systems. Schematics are showing the proposed mechanisms.

Reference

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Return to program.

[1025] Maillard Reaction control in condensed biopolymer/co-solute model systems

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In condensed hydrocolloid systems, the mechanical glass transition temperature (T_{gm}) determined rheologically successfully captures the contributions of a network forming biopolymer to the material's vitrification behaviour[1]. In high solid hydrocolloid/co-solute model systems, it has been shown that the arrest in segmental relaxation at T_{gm} coincides with an arrest of small molecule diffusivity[2], underscoring the potential of this method in the production of controlled-release functional foods. This idea has recently been expanded upon to also define T_{gm} as an index of quality control, showing that lipid oxidation kinetics are contingent upon the availability of the system's free volume, and that the T_g defined calorimetrically (T_{gc}) appears unsuitable to capture the onset of segmental motion in such mixtures[3,4].

The present work therefore expands on these ideas, now examining whether T_{gm} can also be used as an index to control the rate of Maillard browning in model food systems. It proposes that there will again be predictive differences between T_{gc} and T_{gm}, suggesting that T_{gm} better represents the entirety of the system's physical state. To achieve this, the glass transition temperature of porcine gelatin in the presence of glucose syrup and glucose are derived rheologically and calorimetrically. Upon characterising these temperatures, samples are stored at $T>T_{gm}$ and $T_{gm}>T>T_{gc}$ and the extent of Maillard browning in these systems is quantified.

Results demonstrate that there is an increase in browning at $T>T_{gm}$, but a much less pronounced response at $T_{gm}>T>T_{gc}$. This highlights the ability of T_{gm} to capture the onset of chemical reactivity and again underscores its utility for quality control. Overall, this work further emphasises the importance of accurately characterising the physical state of polymeric systems and may be applied to a range of food and nutraceutical engineering applications in which greater constituent control is necessary.

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Return to program.

[1026] Effects of Drying Methods on Physicochemical and Functional Properties of Lemon Basil Seed Mucilage

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This study investigates the impact of various drying techniques on the physicochemical and functional properties of mucilage extracted from lemon basil (*Ocimum* × *africanum* Lour) seeds. Mucilage samples, containing a solid content of 0.5–0.6 g per 100 g of solution, were obtained via ultrasonic-assisted extraction at 150 W, for 15 minutes, using a 1:40 solid-to-liquid ratio. It is hypothesized that the drying method influences the properties of rehydrated mucilage. The first method, called tray drying (TD), involved drying the extracted mucilage at 60 °C in a petri dish inside a forced-convection oven for

24 hours. The second method, known as drum drying (DD), was performed in a twin-row drum dryer, set at 130 °C and 10 rpm, with the liquid mucilage fed at a rate of 4 kg/h. The third method, called freeze-drying (FD), started by freezing a mucilage sample in a petri dish at -80 °C, followed by sublimation at -65 °C under a vacuum of 0.0001 Pa. The final method, known as spray drying (SP), was carried out in a lab-scale spray dryer using a 0.7-mm fixed nozzle, with an inlet temperature of 170°C, compressed air pressure of 4.0 MPa, and feed flow rate of 0.3 kg/h. All methods were evaluated based on their drying yield and moisture content to assess their drying efficiency. Since the SP produced fine particles, before measuring properties, the mucilage sheets from TD and FD, and the mucilage flakes from DD, were ground into powder with particle sizes less than 0.1 mm to normalize particle size effects. The physicochemical properties, including density, viscosity, and molecular weight distribution, were analyzed. Furthermore, the functional properties evaluated included water and oil holding capacities, emulsification capacity and stability, water solubility, color, water activity, dispersion stability, and moisture content.

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[1029] Plant cell wall-polyphenol interactions modulate starch functionality, digestibility and the prebiotic outcomes of the tertiary system

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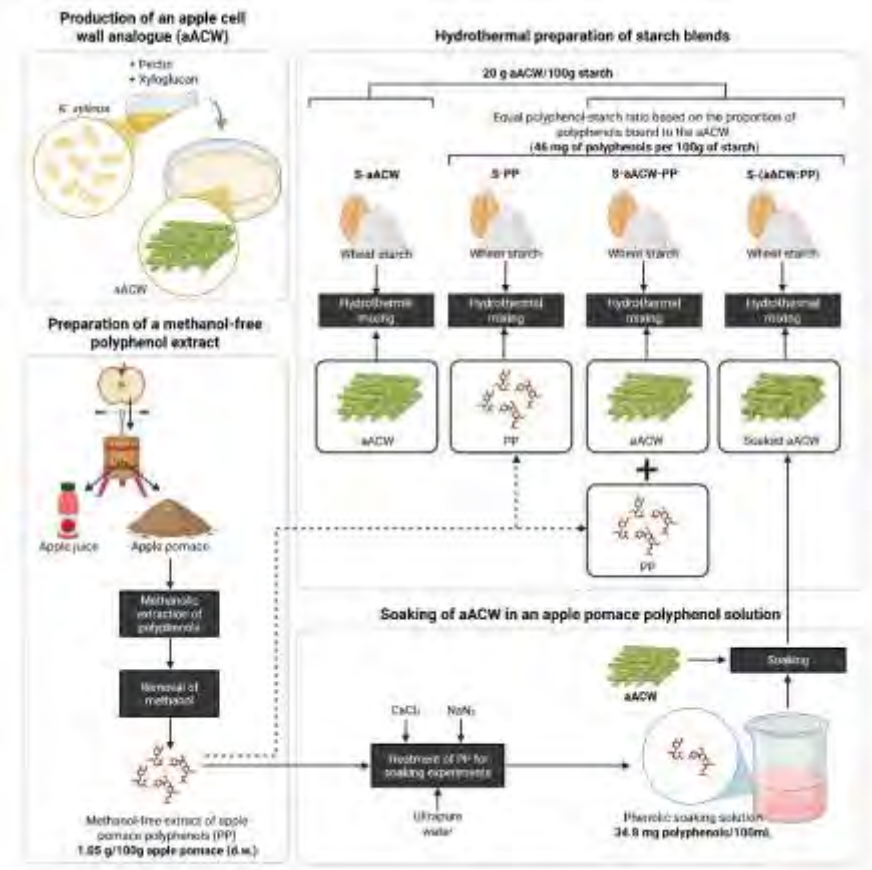
Starch, dietary fibre, and polyphenols are key components of plant-based foods whose coexistence in carbohydrate-rich matrices defines both food structure and nutrition. While increasing attention has been given to pairwise interactions among these components, their combined (three-way) interactions remain poorly understood and are rarely captured in real food systems or clinical studies. Understanding pairwise, and particularly three-way, interactions require carefully designed and representative study models. This is especially challenging for plant cell wall materials, which must capture their chemical and supramolecular complexity, and for phenolic compounds, which should reflect their structural diversity and glycosylation patterns. To address this, we developed a model system in which component composition, structure, and concentration were tightly controlled. The model encompassed wheat starch, a bacterial cellulose analogue of the apple cell wall (aACW), and an apple pomace polyphenol extract, ensuring integrated chemically complex cell wall polysaccharides and a real mixture of apple polyphenols, predominantly glycosylated, assembled into supramolecular structures that mimicked the native deposition of cellulose within the polysaccharide matrix of plant cell walls (**Figure 1**). Blends - starch + polyphenols (S-PP), starch + aACW (S-aACW), starch + aACW + polyphenols (S-aACW-PP), and starch + polyphenol-preloaded aACW [S-(aACW:PP)] – ensuring consistent starch-aACW-polyphenol ratios were subjected to simulated hydrothermal processing (RVA), storage, and in vitro digestion using the INFOGEST model with pooled human saliva. Gut microbial responses were tested using *in vitro* fecal microbiota batch fermentations. The presence of polyphenols in both starch and S-aACW lowered pH and significantly reduced granular swelling and increased breakdown upon heating. These reductions in granular swelling were mitigated when polyphenols were pre-loaded within aACW, while their aACW-entrapment had no effect on breakdown, setback (short-term retrogradation), or water mobility. During storage, the inclusion of polyphenols or aACW increased the enthalpy of retrograded amylopectin, an effect intensified by combining free polyphenols and aACW (S-aACW-PP) but not when polyphenols were pre-loaded within aACW [S-(aACW:PP)]. aACW and polyphenols individually reduced starch digestibility. Notably, this effect at the end of the intestinal phase persisted only with free polyphenols, not with those pre-bound to aACW. Remarkably, beta-diversity analyses revealed strong clustering by treatment (including S-aACW-PP and S-(aACW:PP) despite their compositional similarity), underscoring the role of aACW-polyphenol interactions in modulating dietary fiber's prebiotic effect in starchy systems. These results demonstrate that the properties and bioactivities of starch, dietary fibers and

phenolic compounds are interdependent in products containing them, such as whole grain products and formulated plant-based foods products fortified with phenolics and fibers. Results may therefore contribute to enhance the design, formulation and production of food products for health, beyond simply the content in bioactive nutrient and towards actual functionality.

Figure 1. Step-wise approach followed to create a model system in which component composition, structure, and concentration were tightly controlled. Consistent polyphenol-starch, polyphenol-aACW, and aACW-starch ratios were used at concentrations representative of real food systems.



Return to program.

[1030] Enhanced delivery and bitterness masking of appetite-suppressing hop bioactives using hydrocolloid microgels: A structure-function design for enhanced palatability, stability, and bioaccessibility

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Amarasate® is a bitter extract derived from New Zealand hops, recognised for its appetite-suppressing properties, and is currently used as a dietary supplement. However, its intense bitterness, stickiness, and the instability of its bioactive compounds (alpha and beta acids) present significant challenges for incorporation into functional food products. This study addresses these limitations through a targeted encapsulation strategy aimed at improving stability, controlling release, and enabling integration into diverse food systems using food grade hydrocolloids.

Initial formulation involved the development of water-in-oil emulsions (365 nm) stabilised with oil, soy lecithin, and whey protein. These emulsions demonstrated high stability over 14 days and were successfully converted into dry powders via spray- and freeze-drying, retaining bioactive integrity and exhibiting excellent dispersibility across various food matrices. However, sensorial analysis identified remaining issues with palatability.

Accordingly, to further enhance delivery efficiency, bioaccessibility, and palatability, four microgel formulations were developed using different ratios (2:1:1 to 2:1:10) of sodium alginate, gelatin, and maltodextrin through microgelation and co-extrusion techniques. Encapsulation was performed using an InoTech Encapsulator and scaled up with a Büchi B-390 Encapsulator.

The resulting microcapsules (about 150 µm; wet beads) were hardened, UV-cured, and freeze-dried. In vitro gastrointestinal digestion studies confirmed effective protection of hops bioactives during the simulated gastric phase, with up to 75% release of adhumulone and complete (100%) release of adlupulone during the intestinal phases, demonstrating both protective encapsulation and targeted release.

The encapsulated ingredient was successfully incorporated into a range of food formulations. Sensory trials validated the encapsulation approach, with the scaled-up formulation achieving about 75% consumer acceptability rate across all tested

applications. Minor residual bitterness, attributed to surface oil, suggests scope for further refinement.

Overall, this work presents a structure–function-guided encapsulation strategy that enhances chemical stability, shelf life, bioactive bioaccessibility, and ingredient palatability, supporting the integration of Amarasate® into functional food systems and future clinical applications.

Keywords: Nutrient bioaccessibility; Bitterness masking; Functional foods; Bioactive microencapsulation; Biopolymer microgels.

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[1031] Towards a Kinetic Understanding for Protein–Phenolic Interactions in the High Temperature Regime

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Food processing routinely exposes our food systems to often harsh thermal treatments, that are primarily aimed at reducing/eliminating microbial load, hence improving safety and shelf life[1]. However, it has long been known that at these elevated temperatures, the available chemical pathways for spontaneous chemical reactions between food ingredients is substantially broadened, and their kinetics enhanced[2]. Modern formulation strategies, i.e., the increased use of plant based ingredients in traditionally animal based products for health and environmental benefits, has substantially broadened the diversity of reactive chemical species in our food formulations. Amongst these, are phenolic compounds, generally regarded as beneficial to health thanks to their antioxidant properties, these microconstituents are present in almost all plant

based ingredients, and have been found to interact strongly with other food ingredients, with a particular affinity to proteins[3]. Despite the above discussion, most studies on the interactions between phenolic compounds and proteins in food systems are still conducted at ambient conditions and may not necessarily reflect how these ingredients behave under a high temperature regime.

The outcome of recent, high temperature research, shows that phenolic acids interact chemically rather than physically with both plant and animal proteins at elevated (~90-140°C) temperatures and neutral conditions, permanently altering the protein and its functionality. *In silico* analysis demonstrates that thermally induced structural changes to the proteins appear to have a significant effect on the availability of binding sites for phenolic compounds and may facilitate covalent bond formation[4]. The present work summarises the current state of the art in this area and proposes experimental approaches that may better describe how protein–phenolic interactions evolve within the high-temperature regime. Key focuses involve adaptation of experimental setups to achieve in situ observation of bond formation in real time, rather than post processing. Further, making use of recent advancements in docking and molecular dynamics techniques that predict covalent bond formation can provide an additional mechanistic view of how these interactions may occur. Such understanding will enable a molecular level explanation of frequently reported effects to protein functionality upon covalent complexation with phenolics. Hence, facilitating the rational design of thermally processed foods where structural modification, digestibility, and antioxidant behaviour can be intentionally tuned.

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Return to program.

[1033] Gelation mechanism and network structure of gellan gum in low and high concentration of sucrose solutions

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Gellan gum has been increasingly applied in producing gelatin-free soft candies due to its strong ability to form clear and transparent gels. However, the understanding on the gelation mechanism and network structure of gellan gum in solutions with high co-solute contents are still insufficient. In this study, we have studied the gelation behavior of 1.0% deacylated gellan (DG) in a wide range of sucrose concentrations (0-80%, w/w) by rheology, NMR, light scattering and molecular dynamic simulation studies. Rheological measurement suggested that addition of sucrose promoted the gelation process of DG in a concentration-dependent manner, and above 40% sucrose concentration, DG exhibited a tendency to form a rubber-like gel network, as confirmed by transmission electron microscopy and light scattering measurements. Further investigation of LF-NMR relaxometry suggested that the apparent T_2 relaxation time of DG in low concentrations of sucrose solutions (<40%) significantly decreased at the gelling temperature, indicating a diffusional confinement of the forming DG network on the motion of sucrose and water molecules. At higher sucrose concentrations, however, the

apparent T_2 relaxation time exhibited a smooth and progressive decease, which was ascribed to the high viscosity of the systems that greatly decreased the molecular mobility of sucrose and water and made the change in the apparent T_2 relaxation time less obvious. Furthermore, molecular dynamic simulation was applied to reveal the aggregation behavior of DG in different concentrations of sucrose solutions. As expected, increasing amount of sucrose addition decreased the radius of gyration of DG but promoted the crosslinking extent of DG chains, suggesting a possibility that DG chains formed a gel network with entropic elasticity origin. Overall, our study is believed to provide useful knowledge on understanding the gelation process and network structure of DG in different concentrations of sucrose solutions, which may be useful to designing gelatin-free soft candies with versatile textures.

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[1034] Protein dry spinning as a bottom-up approach for the design strategy of anisotropic structures in plant-based meat analogues.

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Replicating the fibrous hierarchy of muscles remains a key challenge in plant-based meat analogues. While top-down structuring (e.g., extrusion or shear cell) relies on

macroscopic structuring, bottom-up approaches such as dry spinning enable the fabrication of defined fibers made of proteins. This study aimed to (i) elucidate the multiscale structure of dry-spun plant protein fibers and (ii) evaluate their potential as building blocks for spun meat analogues by comparison with bovine muscle (entrecôte). Dry spinning is a fiber-forming method in which proteins are processed into continuous fibers under controlled conditions. In contrast to extrusion, this approach allows for more precise control over fiber properties and thus offers potential for creating anisotropic structures in plant-based meat analogues.

Formulations based on wheat gluten, mixed with or without faba bean protein isolate, and supplemented with or without salt were dry spun. Structural characterization was conducted across several length scales: macro (photography), meso (scanning electron microscopy, SEM; confocal laser scanning microscopy, CLSM), and micro (solubility tests). Texture profile analysis (hardness, springiness) enabled benchmarking against entrecôte.

Dry spinning yielded hierarchically organized, anisotropic fiber bundles with parallel alignment. Gluten-only fibers exhibited smooth and compact surfaces, whereas the incorporation of faba bean protein isolate led to rougher surfaces with visible signs of phase separation. In these composite fibers, CLSM revealed a continuous gluten matrix in which faba bean protein isolate appeared as aggregates of varying size and distribution in the fibres. The addition of salt led to more homogeneous networks and a reduction in pore size.

At the molecular level, solubility tests indicated that network stabilization in fibers was governed predominantly by hydrophobic interactions and hydrogen bonds. Compared to gluten alone, blends with faba bean protein isolate exhibited higher hardness and greater springiness, even surpassing that of entrecôte. Despite these differences, the force–displacement curves during the first compression remained similar to meat, suggesting a comparable deformation behaviour.

In conclusion, dry spinning represents a promising approach to producing plant protein fibers that replicate meat-like hierarchy and texture. These results showed the potential of dry-spun fibers as versatile, bottom-up building blocks for high-quality meat analogues with enhanced structural authenticity.

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[1036] The physical properties and microstructure of hybrid processed cheese formulated with plant protein ingredients and rennet casein

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An increasing number of research are exploring plant-based options to either partially or completely replace dairy products due to the environmental concerns related to animal farming, animal welfare issues, personal health considerations. This presentation demonstrated the physical properties of hybrid processed cheese analogues (HPCAs) derived from plant proteins and rennet casein, aiming to understand the spatial and microstructural distribution of these components and their implications for cheese functionalities. The study involves mixing hemp protein or mung bean protein with rennet casein at various ratios to explore the interaction mechanisms among plant proteins, casein, and lipids in hybrid cheese matrices. Comprehensive analysis included rheological properties, solubility, texture profile, meltability, and stretchability of cheese samples. Protein composition and secondary protein structure were studied using SDS-PAGE, Raman spectroscopic and FTIR spectroscopy. Confocal microscopy and TEM were employed to visualize the spatial distribution and microstructure of the main components in the cheese matrix. The results revealed significant variations in the physical properties and microstructure of HPCAs based on plant protein types and plant protein to casein ratio. The addition of 30% or more plant protein affects the physical and textural properties and microstructure of cheese analogues, with poor fat emulsification. Mung bean protein-based HPCAs exhibit better stretchability, rheological, and textural properties, but not meltability, compared to the hemp protein system at the same mixing ratios. This difference is possibly related to the size of the

plant protein aggregation. These findings deepen our understanding of plant protein-based and hybrid cheeses, paving the way for optimized plant-based dairy alternatives.

Return to program.

[1042] Disentangling viscosity from non-catalytic binding in α-amylase inhibition

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The inhibitory effects of dietary fibre on digestive enzyme kinetics are poorly understood, which limits the development of fortified foods and nutraceuticals. While inhibition is frequently attributed to viscosity effects, additional physicochemical interactions, including non-catalytic binding may also play a role[1,2]. To clarify these mechanisms, the present study isolated viscosity as the sole variable affecting alpha amylase activity, thus providing a framework for understanding how the physical properties of a food matrix can modulate digestive enzyme function[3].

Gelatin solutions (0.01-0.2% w/v) were prepared from porcine gelatins of varying bloom strength (100, 175 and 300g) to determine the critical concentration range at which viscosity begins to significantly impact enzyme kinetics. Alpha amylase activity was measured using soluble starch as a substrate under controlled conditions (pH, enzyme concentration and viscosity). A clear inverse relationship was observed, indicating that the rate of substrate diffusion to the active site is limited in viscous media. To confirm that the inhibition was solely dependent on viscosity, complementary analyses were performed using fluorescence spectroscopy, confocal imaging and molecular dynamics simulations. These approaches revealed no significant binding interactions or structural alterations of alpha amylase in the presence of gelatin, thus supporting the conclusion

that, in this system, reduced enzyme activity arises from rheological constraints imposed by increased viscosity rather than consequential molecular interactions.

This study demonstrates that viscosity alone can significantly inhibit alpha-amylase activity in the absence of binding, thereby identifying a key physical mechanism underlying dietary fibre-enzyme interactions. These findings provide the foundation for future work which aims to disentangle the impact of viscosity and non-catalytic binding both of which are suspected to be at play in systems containing dietary fibre. Success along these lines, would offer practical guidance for the development of fortified foods and nutraceuticals aimed at glycaemic control.

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Return to program.

[1044] Fractionating cereal brans into functional polysaccharides through subcritical water extraction

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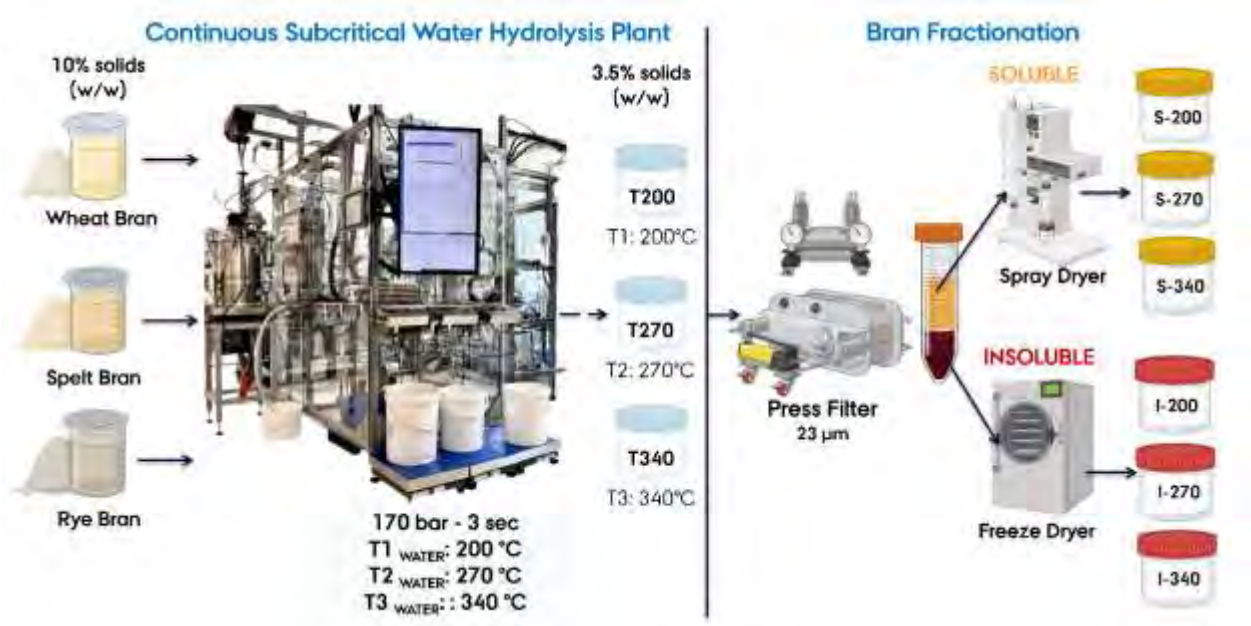
Cereal brans, the main by-products of grain milling for white flour production, represent 13-17% of the grain weight and are rich in dietary fiber (DF), minerals, and bioactive compounds. Bran by-products are still utilized in low value applications such as animal feed or bioethanol manufacture**.** However, their use in whole foods is limited by the presence of antinutrients (e.g., phytic acid (PA)) and high recalcitrant and insoluble DF, which negatively affect the hydration and rheological properties of other biopolymers in the food matrix, leading to deleterious texture and sensory perception. Traditional physical treatments like particle size reduction or high-shear extrusion have been utilized to improve bran functionality, but neither sufficiently enhancing fiber solubility or reducing PA levels, due to their high thermal stability. Subcritical water (SW) treatment, which uses controlled pressure and temperature for biomass hydrolysis at decentralized locations, offers a promising green alternative to boost soluble DF and reduce antinutrients. At subcritical water conditions (> 5MPa, 100-374 ºC) the presence of hot pressurized liquid water would allow for fast hydrolysis reactions of bran biopolymers, with high efficiency. Therefore, this work aims to understand the effect of various SW treatments on the composition and functionality of bran fractions from rye, wheat, and spelt sources (Figure 1). Bran fractions were treated in a continuous hydrolysis plant with SW at three different temperatures (200, 270, and 340 °C) and constant pressure (17 MPa). Following these SW treatments, treated brans were filtered and fractionated into soluble and insoluble fractions. The brans were compositionally characterized, including polysaccharide and mineral composition, PA, and starch content as well as structurally analyzed using microscopic, chromatographic and FTIR tools. For functionality, foaming, water absorption, viscosity and solubility were evaluated. Increasing SW temperature resulted in a higher ratio of soluble to insoluble fiber fraction for the three cereal sources, especially for wheat brans. Filtration after SW treatment removed small-molecular weight compounds (e.g., sugars) and depleted starch in the insoluble fraction, particularly at 340 ºC, concentrating these compounds in the soluble fraction. Insoluble fractions exhibited higher fiber (~75%) and protein (9-12%) concentrations than control brans. FTIR and chromatographic analyses also suggested that both proteins and cell-wall polysaccharides (i.e., arabinoxylans) suffered from hydrolysis due to the SW treatment. Regarding microstructure, control brans had fibrillar and compact heterogeneous particles, while the insoluble fractions had less compact,

honeycomb-like structures. The soluble fractions showed smaller and spherical particles with concavities, resulting from spray-drying. Mineral analyses revealed higher potassium and phosphorus contents in the soluble fractions, the latter in agreement with PA hydrolysis/solubilization. PA levels were lower in treated samples than controls, with higher SW temperatures further reducing PA content. Regarding functionality, insoluble fractions absorbed more water due to arabinoxylan solubilization, enhanced at higher temperatures, while viscosity decreased due to starch removal and dextrinization. Foaming capacity improved, especially at higher temperatures, in the soluble faction, but stability was negatively affected. Overall, results demonstrated that SW treatment leads to an effective fiber solubilization, starch depletion, and reduced antinutrients, producing a high fiber fraction with improved water absorption and low viscosity, and contributing to their integration in the food matrix for designing fiber-rich baked food applications.

Figure 1. *Step-wise approach followed to process high recalcitrant fiber-rich brans from three cereal sources using a subcritical water hydrolysis (SWH) plant operating at three different temperatures and controlled pressure and time conditions. The obtained treated brans (T) were further subjected to fractionation into soluble (S) and insoluble (I) fractions to further understand the depolymerization of bran polysaccharides (mostly arabinoxylans and residual starch) and fate of antinutrients after the SWH treatment.*



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[1045] Designing Natural Co-Emulsifier Systems: Modified Porous Starch and Soy Lecithin for Egg-Yolk-Free Mayonnaise

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Porous starch (PS) is known for high absorption capacity at temperatures below gelatinisation temperature however, it exhibits limited emulsifying capacity constraining its applications in emulsion-based food systems. Enhancing PS functionality is therefore essential for developing plant-based alternatives to conventional emulsifiers. This study investigated whether modified PS could function as a full or partial replacement for soy lecithin (SL) in high internal phase emulsion (HIPE) designed for egg-yolk free mayonnaise. Modified PS samples were prepared using physical pretreatments (ultrasound (US); alcohol-alkaline treatment (GCWS) followed by controlled enzymatic hydrolysis with α-amylase and amyloglucosidase. The interaction between modified PS and SL at different concentration (1% - 3%) were examined in relation to interfacial, structural and rheological properties. The result indicated stable emulsion was formed at oil internal phase of 0.75 with particle concentration (1%wt) of SL:modified PS (50:50). Fourier transform infrared spectroscopy confirmed the formation of PS-SL complexes (US-PS-SL and GCWS-PS-SL) through hydrophobic interaction and hydrogen bonds. Addition of SL decreased surface tension of oil/water emulsion, enhanced the gel network strength and apparent viscosity and increased emulsion stability during storage. Modified PS alone was incapable of stabilising emulsions, but incorporation of low SL level markedly improved emulsion structure, indicating that modified PS can partially replace lecithin without compromising its performance. Among the systems

studied, US-PS-SL showed network rigidity which improved stabilisation and resistance to coalescence compared to GCWS-PS-SL.Overall, the findings highlight the potential of modified PS as a natural structuring agent capable of reducing and in some cases substituting, lecithin in HIPE based mayonnaise. This work provides mechanistic insight into starch-lecithin interactions and offers new opportunities for developing egg-yolk-free emulsions using plant-derived co-emulsifier systems.

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[1049] Sustainable active packaging from chitosan infused with extract from pulsed electric field-treated microalgae to preserve quality of chicken fillet

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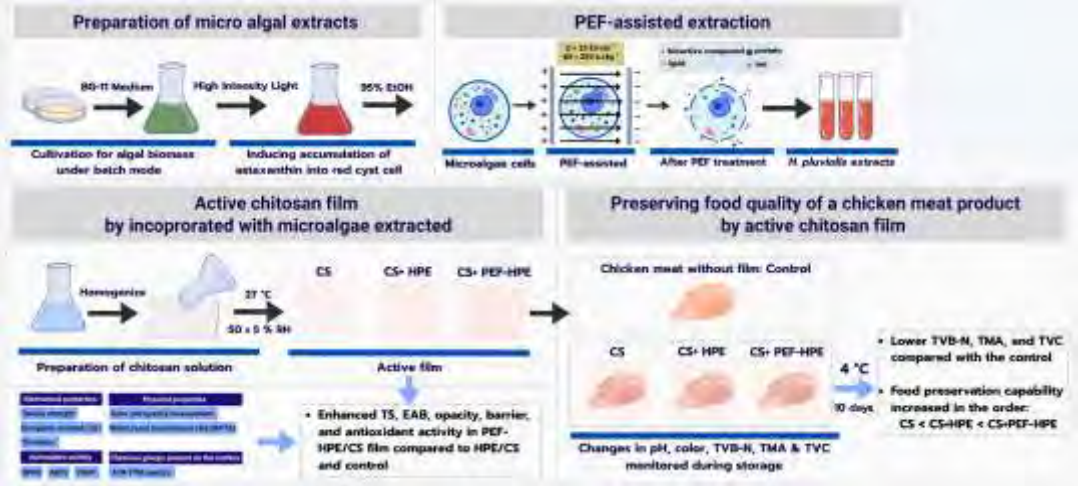
Sustainable active film from chitosan (CS) incorporated with microalgae *Haematococcus pluvialis* extract (HPE) was developed. Pulsed electric field (PEF) with the field strength of 25 kV•cm^{-1} and total specific energy of 200 kJ•kg^{-1} was optimal to extract *H. pluvialis* by inducing the electroporation in the cytoplasmic membrane, resulting in improving the solvent-mediated extraction of the bioactive compounds, as evident by the analysis results of GC-MS and HPLC-MS. The active film was then fabricated by infusing CS with HPE or PEF-assisted HPE (PEF-HPE), and characterized for tensile strength, elongation, opacity, water vapor barrier and antioxidant activity. The optimal CS+PEF-HPE film was then used to wrap chicken fillet, in comparison to CS and CS+HPE. Chicken meat without film wrapping was used as control. All samples were stored at 4 °C

and monitored for changes in color, total volatile basic nitrogen (TVB-N), trimethylamine (TMA), total viable counts (TVC) throughout the storage. Chicken breast wrapped with CS, CS+HPE and CS+PEF-HPE had significantly lower TVB-N, TMA, TVC than control samples during storage. The food preserving capability of the fabricated films increased in ascending order from CS, CS+HPE, to CS+PEF-HPE. These results indicated the fabricated CS film synergized with microalgae extract has potential as active packaging to preserve quality and extend shelf-life of chicken meat.



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[1050] Absorption of *Enteromorpha prolifera* Polysaccharides in Mice and the Protective Mechanism Against Alcohol-Induced Damage in L02 Cells

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Enteromorpha prolifera polysaccharide (EP) has previously been shown to protect against acute alcoholic liver injury in mice. To investigate the absorption potential of EP, the EP was labeled with FITC. EP-FITC was administered to mice to investigate the in vivo absorption of polysaccharides. A Caco-2 cell-based intestinal barrier model was employed to investigate EP's transport mechanism. Based on this, an alcohol-induced injury model was established in L02 cells to investigate the protective mechanisms of EP and purified EP2 fraction against alcohol-induced injury, focusing on alcohol metabolism, antioxidant capacity, apoptosis, and mitochondrial damage.

The fluorescence-tracking analysis revealed that EP-FITC appeared in the liver 2 hours after and was clearly detectable 6 hours later. Pale fluorescence was detected in the kidney 12 hours later, indicating that the EP can be excreted in the urine. Results demonstrated that EP-FITC was successfully traversing the Caco-2 intestinal barrier.

The viability of alcohol-damaged L02 cells showed a dose-dependent increase with EP and EP2 concentrations ranging from 20 to 100 μg/mL, indicating that both EP and EP2 protect L02 cells. EP and EP2 significantly restrain AST and ALT activity as well as NO and MDA levels in alcohol-damaged cells while markedly enhancing SOD activity. The optimal reduction in AST and ALT activity was observed at 100 μg/mL EP and EP2, whereas the most significant enhancement in SOD activity occurred at 50 μg/mL; EP and EP2 enhanced ADH/ALDH activity to accelerate alcohol metabolism and downregulated the expression levels of apoptotic proteins BAX, Caspase-3, and Caspase-9, thereby mitigating alcohol-induced abnormal cell apoptosis. Furthermore, EP and EP2 reduce mitochondrial damage by boosting mitochondrial membrane potential, lowering ROS buildup, and activating the Nrf2/HO-1 signaling pathway through increased Nrf2 phosphorylation. This study demonstrated that the oral polysaccharide can reach the liver to protect against acute alcoholic liver injury in mice.

- Bioactive polysaccharides for human health

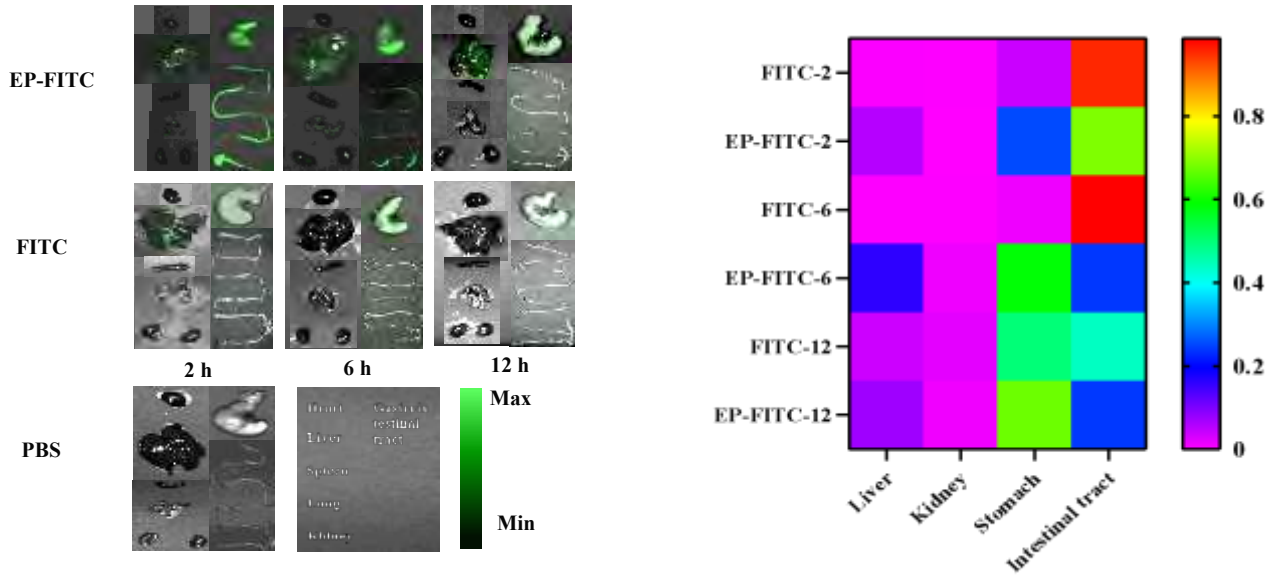

Figure: In vivo biological distribution of EP-FITC

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[1053] Modeling and simulation of phase inversion processes going from fresh cream to butter via whipped cream by a complex systems approach with Coupled Map Lattice

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Fresh dairy cream (O/W emulsion) is a naturally complex food consisting of multi-component, multi-phase, and multi-scale materials and interfaces that undergoes a phase inversion phenomenon of turning into butter (W/O emulsion) via whipped cream

by mechanical whipping. Thus, there are high technical barriers to the modeling and simulation of the phase inversion, such as consistent approximation in macroscopic equations and massive computation in microscopic simulations. This modeling complexity inherent to food can be easily addressed by employing a complex systems approach, Coupled Map Lattice (CML), which flexibly describes elementary processes by parameterized nonlinear maps. CML has successfully reproduced various complex phenomena such as nucleate to film boiling, soft to hard turbulence, stratus to cumulonimbus cloud formation, and spiral arm to stellar and substellar companion formation [1, 2].

We have proposed a CML for understanding the formation and self-organization of diverse food texture patterns appearing in the phase inversion processes [3]. The proposed CML has three field variables, surface energy, cohesive energy, and velocity (flow) of the virtual emulsion defined on a two-dimensional square lattice, and is constructed by the three simple procedures (i.e., nonlinear maps with cooking parameters), whipping, coalescence, and flocculation, acting on the field variables. In the simulations, two different phase inversion processes are reproduced at high and low whipping temperatures. The overrun and viscosity changes in these processes are at least qualitatively consistent with those in experiments. The two processes give rise to distinctive spatial patterns of overrun (surface energy) and viscosity (cohesive energy), and are characterized on the viscosity-overrun plane, a macroscopic state diagram, as the viscosity dominance at high whipping temperatures and the overrun dominance at low whipping temperatures, while on the particle size-density plane, a microscopic state diagram, as the isodensity size dominance and the isosize density dominance, respectively.

The butters obtained at high whipping temperatures are large size and low density and thus low overrun and viscosity, so to say, have a *soft and creamy* texture, while those obtained at low whipping temperatures are small size and high density and thus high overrun and viscosity, so to say, have a *hard and fluffy* texture. In the presentation, we will explore the theoretical design of a new texture (*fluffy and creamy with moderate firmness*) by controlling the cooking parameters of the CML procedures based on this relationship between the macroscopic texture and microscopic structure.

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[1054] Polyphenols modulate faecal fermentation of dietary fibre depending on polysaccharide chemistry and supramolecular assembly

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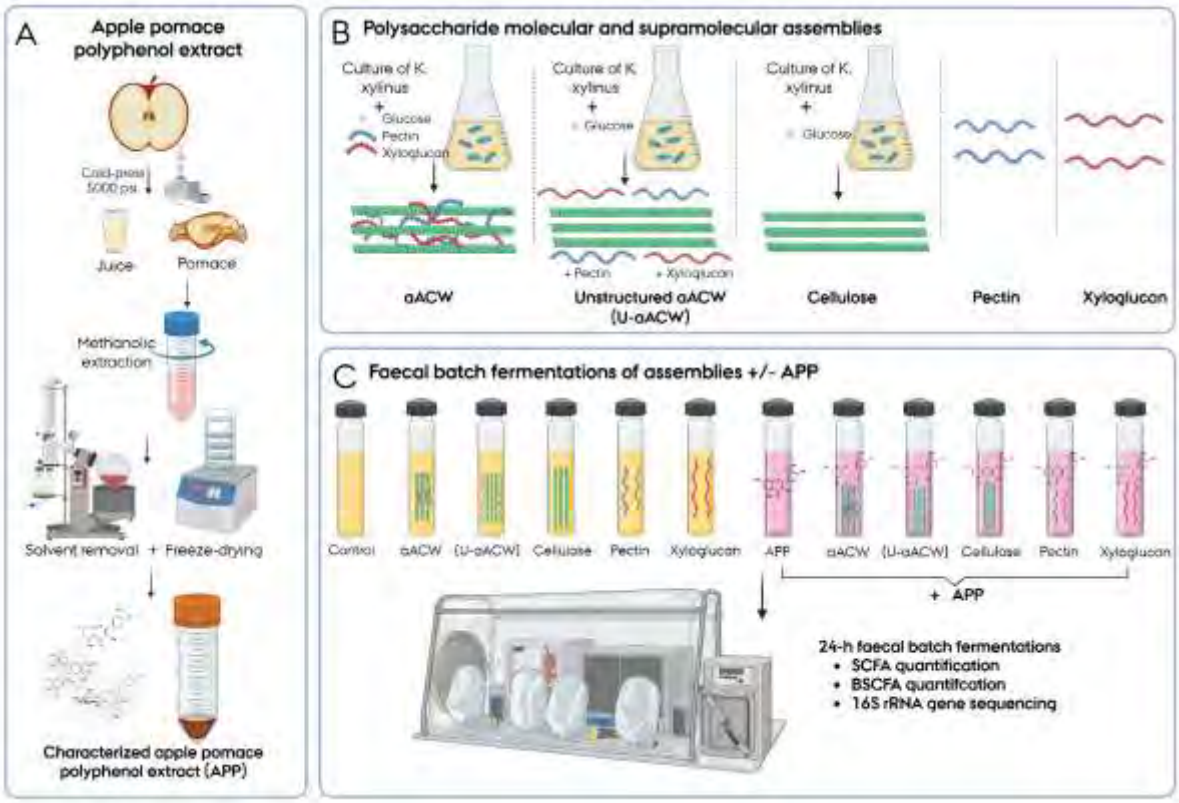
Compositional and structural differences among dietary fibres (DFs) impact their utilization by the gut microbiota. Additionally, DFs have gained increasing attention for their crucial, yet less well-understood, role in facilitating the colonic delivery of bioactive compounds. Previously, we showed that apple cell wall analogues (aACWs) can bind and gradually release apple-derived polyphenols during faecal fermentation, transiently enhancing acetic acid production. In some donors, retained polyphenols influenced as many or more microbial families than the aACWs themselves. However, whether these effects extend to individual polysaccharides or unstructured mixtures, and how fibre architecture shapes polyphenol-mediated microbial metabolism, remains unclear. This study aimed to determine how a physiologically relevant polyphenol extract modulates

the prebiotic potential of dietary fibres and to distinguish the roles of fibre chemistry and supramolecular organization in governing these effects. To this end, we used a well-defined, modifiable aACW produced via bacterial synthesis of cellulose with concurrent incorporation of pectin and xyloglucan, reproducing the hierarchical polysaccharide architecture of plant cell walls. In addition, we employed an unstructured blend (U-aACW) of the same components, as well as the individual polysaccharides (cellulose, pectin, xyloglucan, Figure 1). Each substrate was tested alone or with an apple pomace polyphenol extract (APP) at an intestinally relevant concentration in 24-h faecal batch fermentations. Alongside short-chain fatty acids (SCFA: acetate, propionate, butyrate) and microbiota composition (16S rRNA sequencing), underexplored branched SCFA (BSCFA: isovalerate, isobutyrate) were also quantified. Results showed that pectin and xyloglucan generated the highest SCFA concentrations (67.8 and 64.3 mM), followed by the three-component composites (aACW and U-aACW; ~47 mM), and cellulose the lowest (31 mM). BSCFA, associated with proteolytic metabolism, showed the opposite trend and was highest with cellulose (2.06 mM). Addition of APP consistently shifted metabolism toward carbohydrate-derived SCFA and away from BSCFA. After 24 h, aACW and cellulose exhibited the strongest APP-induced SCFA enhancement ($\log_2$ fold change ≈ +0.25), whereas U-aACW, pectin, and xyloglucan showed smaller increases (+0.12 to +0.14 $\log_2$ FC). Conversely, APP addition led to transient reductions in BSCFA that persisted modestly in structured systems (aACW and cellulose; −0.1 to −0.13 $\log_2$ FC). These results indicate that polyphenols most effectively enhance beneficial fermentation when the substrate is structured and slowly degradable. Taxa β-diversity and hierarchical clustering revealed four substrate-driven groups (control/cellulose, aACW/U-aACW, xyloglucan, and pectin), indicating that fibre chemistry predominantly determines community composition, with minimal influence from APP. Correlation analyses linked a broad set of taxa with metabolic outcomes—for example, SCFA production correlated with *Blautia*, *Parabacteroides*, and *Faecalibacterium* (typically linked to eubiotic gut states) whereas BSCFA correlated with *Negativibacillus* and *Peptoclostridium* (associated to dysbiosis). APP selectively modulated these taxa, enhancing SCFA-associated and suppressing BSCFA-associated groups, particularly within structured fibres, consistent with the observed metabolic shifts. Overall, polyphenol addition caused only minor global changes in community structure but consistent, targeted modulation of taxa central to SCFA/BSCFA metabolism. These focused responses, most evident in structured and slowly fermentable matrices, amplified beneficial metabolic outputs.

Figure 1. Overview of the experimental design and conceptual framework.



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[1055] Modified marama bean concentrate as an alternative to gluten protein

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Marama bean is a climate-smart crop, gluten-free and can grow in the Kalahari Desert. Marama bean protein has been shown to exhibit viscoelastic properties, although not as

pronounced as those of gluten proteins in wheat. The objective was to determine the effect of laccase enzyme with tannic acid on the rheological properties of dough made from Marama bean concentrate. The protein concentrate was modified with tannic acid (4% w/w) and a commercial laccase enzyme (0.5%, 1%, and 5% w/w) alone and in combination. Rheological tests on dough made from unmodified and modified Marama bean protein concentrate included amplitude sweeps, frequency sweeps, and creep–recovery analyses. Structural changes were evaluated by LC-MS, FTIR, and dynamic light scattering. Dough from modified Marama bean with tannic acid and laccase enzyme showed a higher linear viscoelastic range compared to the control. The highest strain was for the tannic acid–laccase treatments. Similarly, dough from the modified protein exhibited higher storage and loss moduli for frequency sweep compared to the unmodified protein, indicating a greater degree of molecular entanglement. In creep–recovery tests, dough from modified protein with 0.5% laccase, combined with tannic acid, showed a similar recovery to vital gluten. Dough from treated protein samples exhibited higher elasticity compared to the control. Structural analysis showed a reduction in β-sheets and β-turns, and an increase in random coils and α-helices for modified proteins. LC-MS showed the formation of di-tyrosine crosslinks in modified proteins. In conclusion, tannic acid in combination with laccase can produce Marama protein dough with viscoelastic properties similar to those of vital gluten, resulting from secondary structural changes and dityrosine cross-links. These changes in the rheological properties showed good potential in gluten-free bakery applications.

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[1056] Modulation of interfacial and foaming properties of cow milk under non-rancid lipolytic conditions

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The formation and stability of milk foams are governed by milk proteins that adsorb at the air-water (AW) interface to form viscoelastic films capable of entrapping air and maintaining foam structure. Foam quality is a defining attribute of many dairy-based coffee beverages (*e.g.*, cappuccinos, lattes, macchiatos), where stable foams prolong the release of coffee aroma and enhance sensory perception. However, poor foaming remains a recurring issue in the preparation of such beverages when using pasteurized fresh milk rather than barista formulations enriched with stabilizers, such as protein concentrates. This problem has been attributed to lipolysis, the enzymatic hydrolysis of triglycerides into free fatty acids (FFAs), monoacylglycerols (MAGs), and diacylglycerols (DAGs). Among these products, FFAs have been extensively regarded as key contributors to milk foam destabilization. However, previous studies have primarily focused on rancid milk, characterized by elevated FFA levels (>3.8 mmol/100 g fat), even though poor foaming has also been observed in non-rancid milk. This suggests that other lipolytic products may also influence foaming behavior, yet the role of sub-rancid lipolysis remains largely unexplored. This study investigates how limited lipolytic activity alters the composition of surface-active lipids and consequently affects the interfacial and foaming properties of milk. Cow milk was incubated with 1(3)-regiospecific *Aspergillus niger* lipase at concentrations ranging from 0.2 to 200.0 mU/mL at 37 °C for up to 180 min. Foaming properties were assessed following steam injection using a commercial espresso machine, while interfacial rheological properties (dilational elastic and viscous moduli, ε’ and ε’’) were analyzed via pendant drop tensiometry. The relative proportions of FFAs, MAGs, and DAGs were quantified by gas chromatography. The absence of lipolytic rancidity was verified through pH monitoring and FFA quantification by attenuated total reflectance Fourier-transform infrared spectroscopy. At early stages of lipolysis, the accumulation of FFAs and DAGs corresponded with reductions in ε’ and foaming capacity, indicating that these products disrupted the formation and stability of protein films at the AW interface. As lipolysis progressed,

increasing MAG concentrations partially counteracted these effects, resulting in improved foaming properties. This improvement coincided with an increase in ε', suggesting the formation of a more elastic and cohesive interfacial film, likely arising from cooperative interactions between MAGs and milk proteins. At higher lipase concentrations (≥ 20.0 mU/mL), excessive MAGs again reduced ε' and impaired foam stability, likely due to protein displacement from the AW interface. Across all treatments, milk pH remained stable and FFA levels (0.68–2.10 mmol/100 g fat) were below the rancidity threshold, confirming that the observed changes in interfacial and foaming properties were driven by interactions between proteins and lipolytic products rather than acidification. These findings reveal that even mild lipolysis can substantially modify the interfacial structure and foaming performance of milk through compositional shifts among lipolytic products. Understanding the functional balance between MAGs, DAGs, and FFAs provides mechanistic insight into the variability of foaming capacity observed under non-rancid conditions.

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[1057] Physicochemical properties of barley lipid transfer protein 1 contributing to beer foam quality

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** Presenting author

Beer foam is a key quality attribute that greatly influences consumer perception and overall beer quality. Proteins play an important role in foam stabilization. Foam formation is driven by protein adsorption at the air–liquid interface, while intermolecular interactions among proteins form interfacial films that enhance viscoelasticity and stabilize the foam. Lipid transfer protein 1 (LTP1), a lipid-binding protein abundant in the aleurone layer of the barley endosperm, comprises eight α-helices that confer high structural stability and prevent precipitation even after boiling during brewing. However, exposure to high temperatures can alter the structure and chemical state of LTP1, ultimately affecting foam properties. Therefore, understanding how heat-induced modifications of LTP1 influence foam stability is essential for producing high-quality beer.

In this study, heat-induced chemical modifications and changes in molecular size distribution and structural characteristics of LTP1 and its lipid-bound isoform, LTP1b, were analyzed using size-exclusion chromatography and reverse-phase chromatography coupled with mass spectrometry. Heating caused lipid adduct dissociation from LTP1b, increased the proportion of deamidated hydrophobic LTP1 molecules, and induced deglycation. Both lipid dissociation and the accumulation of hydrophobic LTP1 molecules were associated with reduced foam quality, indicating that precise control of heating conditions during brewing is critical for retaining functional LTP1b and enhancing foam stability.

We further examined the role of LTP1/LTP1b in the complex beer matrix and monitored their changes throughout the brewing process. LTP1b concentration of commercial beers was 0 to 0.1 μM, and a positive correlation was observed between LTP1b content and foam stability. Supplementation with purified LTP1b improved foam stability more effectively than LTP1; however, LTP1b was added together with other barley proteins, the improvement was limited, suggesting that the relative abundance of LTP1b within the total protein content also affects foam stability. Comparisons among barley cultivars showed that those with higher lipoxygenase (LOX) activity, which is an enzyme involved in LTP1b formation, contained higher levels of LTP1b. Therefore, using barley with lower LOX activity may result in poor beer foam quality. Analysis of samples collected during brewing revealed a reduction in LTP1b during boiling, consistent with results obtained from purified samples, although deglycation was not detected in beer samples. Overall, this study clarifies the molecular basis of LTP1-mediated foam stabilization and offers practical guidance for optimizing both raw material selection and brewing conditions to produce superior beer foam quality.

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[1059] Transforming Watermelon Rind and Pea Protein into a Functional Snack

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Snacks account for nearly a quarter (22%) of total energy intake among adults in the US with more than 90% of them eating one or more snacks on any given day (ref) therefore they make an excellent delivery vehicle for functional ingredients. Watermelon rind, which comprises 40% of the fruit's total weight, is typically discarded despite containing valuable bioactive compounds including L-citrulline (CIT), polyphenols, and dietary fiber (Romdhane et al., 2016). CIT has demonstrated potential to increase muscle mass, function, and athletic performance (Jourdan et al., 2015). Upcycling these agricultural byproducts offers dual benefits of enhanced sustainability and economic competitiveness (Jin et al., 2018). An extruded puff snack was formulated with 0,10,15 and 20% watermelon rind, 20% pea protein (due to the high demand for high protein snacks) and cornmeal (Fig 1). It was hypothesized that increased inclusion of watermelon rind (due to fiber content) would increase hardness of puffed snack and nutrient delivery. Dried watermelon rind, pea protein, and cornmeal were blended prior

to twin-screw extrusion processing at temperatures ranging from 30°C to 150°C across zones 1–8, with screw speed of 600 rpm and moisture content of 20%. HPLC and UV Spectrophotometry were used to quantify CIT and total polyphenols respectively. Hardness was determined using Instron texture analysis.

Results demonstrated significant changes with watermelon rind addition: CIT content increased 2.3-fold (from 14.4 mg/g at 10% to 33.2 mg/g at 20% watermelon rind), total polyphenol levels increased 49 % and hardness increased by 76 %.

These experiments demonstrate that a functional snack can be manufactured utilizing food waste (watermelon rind) that can yield a sustainable, bioactive-rich functional food rich in polyphenols, protein and CIT. Future studies are planned to utilize the watermelon rind puff in a human clinical study.

Fig 1. Puffed snacks containing 0-20% watermelon rind and pea protein. The darker samples had increased % watermelon rind

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[1060] Characterization of gel-forming components derived from mushrooms

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In recent years, demand for gelling agents has expanded due to diversifying food preferences and growing health consciousness. However, the supply of these gelling agents has become unstable due to factors such as climate change and exchange rate fluctuations. Therefore, the development of new gelling agents derived from novel food ingredients is required. The polysaccharide β-1,3-1,6-glucan found in mushrooms has potential as a new gelling agent, and its rheological properties have been studied for various mushroom species. However, previous studies have only suggested gel-forming ability without confirming “true gel” formation. In this study, gelling components were extracted from five major Japanese mushroom species and from *Sparassis crispa*, one of the mushrooms with the highest β-1,3-1,6-glucan content. Their gelling ability was evaluated, and their characteristics were compared.

The extraction as described previously [1] was applied to dried powders of various mushrooms. Briefly, they were defatted with ethanol (80 v/v%) and the resulting residue was dissolved in 0.15 M NaCl to remove salt-soluble substances. The residue from this process was then treated with hot compressed water at 128 °C for 1 h, the resulting suspension was centrifuged and the residue was removed. The supernatant was concentrated using a vacuum rotary evaporator. The concentrate was precipitated with ethanol (40 v/v%). The resulting precipitate was dissolved in distilled water, and α-glucanase treatment was performed only for the sample of *Lentinula edodes*. Trypsin treatment was performed to all samples to degrade the proteins. The treated material was dialyzed against distilled water and then precipitated with ethanol (40 v/v%). The resulting precipitate was dissolved in distilled water again and freeze-dried. The samples were dispersed in distilled water at 1.5 wt% and stirred overnight. The dispersion was heated at 80 °C for 10 min and cooled at 4 °C for 24 h, then gel formation was examined.

The main component of extracts was identified as β-1,3-1,6-glucan from NMR analysis. Gel permeation chromatography indicated that molar mass of all samples except for *Grifola frondosa* was within the range of 107,000 to 365,000. When samples were dispersed in water and cooled after heating, gel formation was visually confirmed for all species of extracts at 4 °C. The *G. frondosa* sample formed a brown gel, while the others formed colorless gels. The *G. frondosa* sample could not be decolorized and was therefore not used in subsequent experiments. Dynamic viscoelasticity and large-deformation measurements showed that extracts from *L. edodes*, *S. crispa, Flammulina velutipes* and *Pleurotus eryngii* formed true gels. The temperature dependence of the storage shear modulus *G*' suggested that conformational transition and gelation occurred below 6–10°C. On the other hand, the *Hypsizygus marmoreus* sample did not form a true gel, probably due to its low molar mass (< 110,000). Among the true gels, *L. edodes* β-glucan gels showed the most fracture-resistant and highest flexiblity. Differences in gel properties were examined not only in terms of molar mass but also based on the degree of side group branching. Furthermore, the binding ability of these gelling components, β-glucans, to a receptor called dectin-1 was also investigated.

Reference

[1] I Yamashita, T Yaguchi, Y Kobayashi, H Ito, H Komori, K Noda, Y Sato, K Nishinari, Y Nitta

Rheology and NMR studies of true gel formation and gelation mechanism for lentinan

Food Hydrocoll., **167**, 111415 (2025)

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[1066] Impact of deep eutectic solvent–tailored nanocellulose on the stability and in vitro semi-dynamic digestion behavior of β-carotene conveying Pickering emulsions

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Nanocelluloses are nanosized materials of crystalline or fibrillar form that exhibit interesting intrinsic properties such as high surface area, crystallinity, wettability, and mechanical strength. Owing to their nanoscale size and good wettability, nanocelluloses can also be applied as solid interface-stabilizing agents known as Pickering particles. Green chemistry-inspired solvents such as deep eutectic solvents (DES) have gained considerable attention compared to organic solvents, as they are inexpensive, have low vapor pressure, are non-flammable, chemically stable, recyclable, biodegradable, and toxicologically well-characterized. Our previous studies have shown that combining DES with ultra-high-pressure homogenization (UHPH) can efficiently transform microcrystalline cellulose (MCC) into cellulose nanofibrils (CNF) with excellent emulsion stabilization capability. The aim of this study was to investigate the Pickering o/w emulsion stabilizing capacity of DES–UHPH-modified CNF at different concentrations and environmental conditions (i.e., temperature, pH, and ionic strength). In addition, the potential of the CNF Pickering emulsions as templates for the delivery of β-carotene was assessed under controlled storage and semi dynamic in vitro digestion conditions.

DES systems composed of choline chloride and urea or malic acid were used for the pretreatment of MCC, following ultra-high-pressure homogenization at 2500 bar. The resulting CNF suspensions were mixed with MCT oil (80/20 w/w) using a sonicator. The obtained emulsions were then stored under different temperature, pH, and salt conditions. The same sonication setup was used for the encapsulation of β-carotene, which was first dissolved in MCT oil. Emulsion storage trials were conducted at 4, 20, 37, 50, and 80 °C, and β-carotene retention was monitored over 30 days. To investigate the in vitro digestion behavior of the β-carotene-encapsulated Pickering emulsion, we applied a novel semi-dynamic digestion system designed to allow gradual gastric/intestinal fluid injection and pH reduction, better simulating human digestion kinetics. Individual pumps with adjustable input rates for different digestive fluids, pH control liquids, and gases were connected to a bioreactor.

Results have shown that the nanocellulose exhibited excellent emulsion-stabilizing capacity across 25–50 °C, pH 4.5–10, and ionic strengths up to 200 mM, demonstrating the effectiveness of DES–UHPH treatments for tuning stabilization mechanisms in Pickering emulsions. Furthermore, the Pickering stabilization effectiveness of nanocellulose particles strongly depends on their morphology, structure, and surface charge density. β-Carotene storage trials showed significantly lower degradation rates in the encapsulated samples compared to β-carotene in bulk oil, especially at high temperatures. In addition, CNF-based Pickering particles efficiently protected β-carotene under UV light. Finally, the implementation of semi-dynamic gastrointestinal digestion, which remains rarely explored due to experimental limitations, offers a more physiologically relevant model than traditional static approaches. The development of nanocellulose-based Pickering systems for encapsulation and delivery of bioactive compounds under such realistic digestion conditions presents substantial potential for advancing understanding and innovation in this field.

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[1067] Advances in understanding the metabolic and hydrocolloidal relevance of fiber-rich fraction from chia seeds

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Hydrocolloids and dietary fibers from novel plant matrices are increasingly recognized for their dual role as technological and bioactive food components. This study reports advances in the structural and functional characterization of the fiber-rich fraction of partially defatted chia (*Salvia hispanica L.*) seeds obtained through cold pressing followed by dry fractionation. The physicochemical and nutritional profile of this hydrocolloidal system was analyzed and evaluated for its preventive effects on metabolic dysfunction-associated steatotic liver disease (MASLD).

The fiber-rich fraction exhibited a total dietary fiber content of 50.2 g/100 g, with a predominance of insoluble fiber (≈90 %), and contained 24.7 g/100 g protein, 10.1 g/100 g lipids, and 6.7 g/100 g ash. Despite partial oil removal, the fraction retained a notable α-linolenic acid content (5.7 g/100 g), conferring the rheological and emulsifying behavior characteristic of chia mucilage–fiber systems. In a high-fat diet (HFD) murine model, supplementation with 20 % w/w of the fiber-rich fraction prevented hepatic steatosis, reduced serum ALT and AST activities, improved lipid metabolism, and partially restored the hepatic n-3 PUFA profile. Moreover, this fiber-rich fraction increased fecal short-chain fatty acids (acetate and butyrate), reduced hepatic F8-isoprostanes, and enhanced the GSH/GSSG ratio, indicating attenuation of oxidative stress. Together, these effects demonstrate the biological potential of dry-fractionated chia hydrocolloids to counteract diet-induced metabolic disturbances.

Ongoing work explores the preventive potential of the chia fiber-rich fraction under early-stage metabolic stress conditions. Current experiments aim to elucidate how the matrix architecture—comprising insoluble fiber, residual protein, and lipid fractions—modulates intestinal permeability, insulin sensitivity, and inflammatory tone before overt hepatic damage occurs. These ongoing investigations are expected to clarify the mechanisms by which chia seed hydrocolloids influence host–microbiota interactions

and redox balance, guiding the development of functional foods designed to prevent metabolic disorders through both technological and physiological pathways.

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[1068] Enhancing Nutritional Value of Baked Products Using Fermented Lucerne (*Medicago sativa*) Flour as an Alternative Protein Source

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Background: The growing global population has increased the demand for sustainable, nutrient-dense protein sources. Lucerne (*Medicago sativa*) seeds are rich in protein and bioactive compounds, and *Lactobacillus* fermentation is known to enhance the nutritional properties of legumes. This study aimed to evaluate the effect of incorporating flours milled from unfermented or fermented lucerne seeds into bakery products (cookies and bread) on phytochemical content, antioxidant activity, protein digestion, and proximate composition.

Methods: Lucerne seeds were fermented using *L. casei*, and flours were prepared from unfermented and fermented seeds. Two replicates of cookies and breads were formulated by partially replacing wheat flour with fermented and unfermented lucerne flour (30% substitution). Both fermented and unfermented flour-based products were analysed for total phenols, flavonoids, and antioxidant activity (DPPH and ABTS assays) using colorimetric assays. The degree of protein hydrolysis (DH%) was determined for the baked products using the OPA assay by quantifying free and total amino groups. In addition, proximate composition was analysed using AOAC protocols.

Results: Incorporation of lucerne flour enhanced the nutritional and functional properties of the baked products. Crude protein content increased by approximately 55% in bread and 41% in cookies following both fermented and unfermented lucerne flour incorporation. Total phenols increased ($P<0.05$) two to three-fold compared to the control, while antioxidant activity increased four-fold in baked products that incorporated fermented or unfermented lucerne flour. Similarly, DH% increased by 31 and 131% in bread made with unfermented and fermented lucerne flour, respectively. A similar trend was observed in cookies, where incorporation of unfermented flour increased DH by 5%, while fermented flour resulted in a 29% increase. In addition, the fermented lucerne flour products had significantly higher ($P<0.05$) total phenols, antioxidant activity, and DH% compared to the unfermented lucerne flour products.

Conclusion: Flour made from fermented lucerne seeds is a highly effective functional ingredient for baked products, substantially enhancing crude protein content, total phenols, antioxidant activity, and protein digestion. Its incorporation into widely consumed foods represents a practical strategy to improve dietary protein intake and support sustainable nutrition in response to the growing global population. Future work to assess the sensory properties and consumer acceptability of these products is therefore warranted.

Return to program.

[1071] Effect of adding thickened aqueous fluid to cooked, minced chicken breast meat on *in vitro* digestibility using human Gastric Digestion Simulator

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Thickening agents are widely used to assist with swallowing in elderly individuals with impaired swallowing function. High-quality protein intake is recommended for the elderly to prevent malnutrition and frailty. However, the effect of adding thickening agents on the gastric digestion of protein-rich foods has not been sufficiently investigated, raising concerns about their impact on nutrient bioaccessibility. A human gastric digestion simulator (GDS) can quantitatively simulate peristalsis on the gastric wall and visualize the digestion behaviors of food particles. In this study, we investigated the effect of adding thickened aqueous fluid to cooked, minced chicken breast meat rich in protein on *in vitro* gastric digestibility behavior using GDS.

Sixty grams of minced chicken breast meat was cooked in a microwave oven and used as the control food sample. Food samples were prepared by adding an aqueous fluid (45 g) containing a xanthan gum-based thickener (2.7 or 5.5 wt%) to cooked meat (60 g). Ten milliliters of artificial saliva was added to each food sample, stirred for 1.5 min, and allowed to stand for 30 s to prepare an artificial bolus. Subsequently, an artificial bolus and gastric juice (240 mL, pH 1.3) were introduced into the GDS vessel. An *in vitro* gastric digestion experiment was conducted at 37 °C for 180 min. The speed and cycle of gastric peristalsis were set to 2.5 mm/s and 1.5 cycles/min, respectively. During digestion, direct observation was performed, and 0.5 mol/L HCl (3 mL) was added every 15 min to adjust the pH of the gastric contents. After the experiment, the gastric digesta was classified using sieves with different mesh sizes (d: 3.35, 2.36, 1.18, and 0.60 mm), and the wet weights of each particle size fraction were measured.

The meat particles gradually disintegrated during gastric digestion in the absence of a thickened fluid, and the release of meat components into the gastric juice was observed. In contrast, the thickened fluid added to heated meat particles partially gelled, which may be attributed to the low pH environment and interactions with cations and proteins in the gastric contents. Moreover, the gel formed adhered to and swelled on the surfaces of meat particles during digestion, suppressing friction between neighboring particles and particle disintegration during digestion. This tendency was particularly pronounced at the high thickener concentration, resulting in a higher retention rate of coarse particles. These results suggest that adding thickened fluid influences digestion behavior in the stomach and that the concentration of thickening agents is an important factor in the design of care foods.

This work was partially supported by the Japan Society Grants-in-Aid for the Promotion of Science (JSPS) KAKENHI Grant Number 24K02892, Japan.

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[1073] Investigating covalent interactions between 11S glycinin and genistein following thermal treatment

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Soy-derived products have been a staple in human diets for centuries owing to their nutritive values including high protein and isoflavone content. Typically, these food products are subject to thermal processing which may modify functional properties and

promote chemical interactions with other components in the system such as isoflavones[1,2]. Soy proteins and isoflavones have been reported to interact non-covalently however, the impact of thermal treatment on the nature of these interactions has not been thoroughly explored[3,4]. In the present work, the effect of thermal treatment on the molecular interactions between glycinin (11S) and genistein (GNE) at 95^{o}C was explored utilising a variety of spectroscopic techniques and in-silico analysis.

The nature of interactions occurring between 11S and GNE were probed using UV-vis absorbance and MALDI-TOF MS analysis. UV-vis revealed a considerable decrease in the absorption spectrum alongside a spectral shift following ligand addition and heat exposure, suggesting a covalent interaction may have occurred. This was confirmed with MALDI-TOF MS analysis, where a mass shift on the acid group was observed, corresponding to the addition of 6 covalently linked molecules of GNE. These covalent additions resulted in minor increases in both alpha helix and beta sheet components of 11S, as confirmed by both FTIR and circular dichroism (CD) analyses. *In silico* analysis revealed the presence of only one binding site under ambient conditions. However, following a simulated thermal treatment which induced changes to protein structure, six distinct binding locations were revealed, in agreement with benchtop experiments. Quantum mechanics calculations demonstrated the possibility of covalent bonds, likely formed *via* an oxidative (quinone) pathway and Michael addition, in each of the proposed binding pockets. These were formed with arginine, alanine and glutamine residues. These findings provide a molecular level explanation of thermally induced interactions in soy protein systems and may assist industry, in developing protocols/procedures to control these effects for specific bio- or techno-functionality.

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Return to program.

[1075] Role of globulins and albumins in oil-water interface properties of coconut meal proteins

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Plant proteins are increasingly explored as sustainable emulsifiers. Coconut protein mainly consists of globulin and albumin, and these individual protein fractions exhibit distinct interfacial behaviors. In this study, globulin and albumin were extracted from supercritical CO_2 (SCO_2) defatted coconut meal, and their interfacial behaviors—individually and in mixture (globulin : albumin = 2 : 1, c/c) were systematically investigated at the oil–water interface. The effects of heat treatment on interfacial film formation and properties were also evaluated, including adsorption kinetics, interfacial dilatational rheology, and interfacial shear rheology.

Compared with albumin, globulin exhibited faster diffusion (k_1 = 6.4 × 10^{-3} in globulin *versus* 3.9 × 10^{-3} in albumin) and rearrangement (k_2 = 0.5 × 10^{-3} in globulin *versus* 0.3 × 10^{-3} in albumin), indicating its greater ability to occupy and reorganize the interface. Heat treatment (90 ℃, 20 min) markedly accelerated both diffusion (k_1 = 41.1 × 10^{-3} in globulin *versus* 20.4 × 10^{-3} in albumin) and reorganization (k_2 = 1.5 × 10^{-3} in globulin

versus 1.1 × 10^{-3} in albumin). These findings suggest that interfacial rearrangement is the rate-limiting step in film formation. The mixture exhibited diffusion (k_1 = 6.6 × 10^{-3} in unheated group *versus* 41.3 × 10^{-3} in heated group) and rearrangement behaviors (k_2 = 0.5 × 10^{-3} in unheated group *versus* 1.7 × 10^{-3} in heated group) similar to globulin, but its interfacial film under dilatational deformation displayed albumin-like characteristics with lower dilatational elasticity modulus (E′ = 13.4 mN/m vs. 20.9 mN/m in globulin), suggesting complementary roles in mixed systems. Moreover, heat enhanced the film elasticity under dilatational conditions.

Interfacial shear rheology further revealed that globulin formed an elastic interfacial network more rapidly and exhibited greater resistance to mechanical deformation (linear viscoelastic region γ_0 = 2.80% in globulin *versus* 1.64% in albumin). The mixture retained globulin-like network formation (γ_0 = 2.25%), implying globulin's dominance under shearing. Notably, heat accelerated network formation but reduced overall film strength (lower G').

Overall, this study elucidates the interfacial mechanisms of coconut protein fractions, providing a foundation for selecting proteins with desired interfacial functionality and offering insights into their potential for emulsion-based applications.

Return to program.

[1076] Rheological, structural, and functional properties of β-glucan from barley and oat

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β-Glucans are soluble dietary fibers predominantly found in cereals and are characterized by β-(1→3)/(1→4) glycosidic linkages, which define their unique structural and functional properties. Barley and oat β-glucans have received approved health claims from regulatory authorities due to their recognized roles in the prevention of metabolic disorders. In this study, the rheological, structural, and functional properties of powdered, concentrated β-glucans from barley and oat were investigated. Rheological characterization included dynamic viscoelastic measurements and steady shear viscosity at 10% and 15% concentrations using an AR-G2 rheometer. Particle size distribution was determined using a Mastersizer analyzer. Structural features were evaluated by FT-IR spectroscopy, size-exclusion chromatography, and differential scanning calorimetry (DSC) to determine thermodynamic parameters. β-Glucan quantification was performed using the Megazyme β-glucan assay kit, and functional properties were assessed by measuring water absorption capacity (WAC) and oil absorption capacity (OAC). Overall, both barley and oat β-glucan powders exhibited similar rheological behavior, with higher shear stress required under increasing shear rates, and storage modulus (G′) exceeding loss modulus (G″), indicating predominantly elastic or solid-like gel characteristics. Oat β-glucan displayed a larger median particle size (d_{50} = 532 μm) compared to barley (d_{50} = 248 μm), whereas barley β-glucan exhibited higher molecular weight and greater β-glucan content. The FT-IR spectra of both samples showed similar structural patterns, with the highest absorption peak between 1000–1200 cm^{-1} corresponding to C–O–C stretching vibrations. Barley β-glucan showed overall higher transmittance values, suggesting subtle structural differences compared to oat β-glucan. The thermal analysis revealed slightly higher, though not significantly different, onset, peak, and endset temperatures, as well as a higher gelatinization enthalpy for barley β-glucan. Regarding WAC, both oat and barley showed similar water absorption capacities, whereas barley exhibited a higher oil

absorption capacity (OAC). These results demonstrate that while oat and barley β-glucans share similar structural motifs, variations in molecular weight, particle size, and rheological behavior may influence their functional performance in food and nutraceutical applications.

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[1082] Influence of apple pomace to modulate the starch and polyphenol bioaccesibility of wheat bread co-formulated with pomace and soluble polysaccharides

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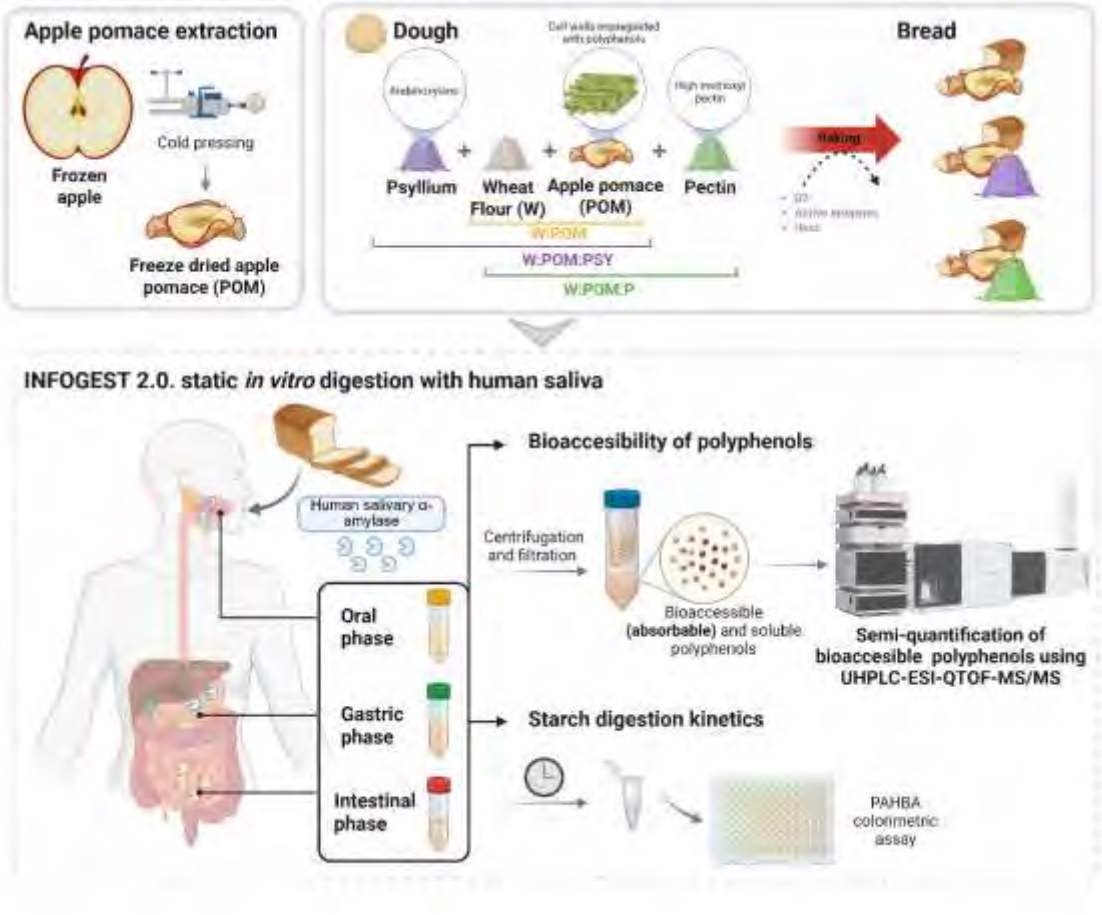
Apple pomace (POM), a major byproduct of the apple juice and cider industries, represents a promising and sustainable source of plant cell walls impregnated with polyphenols. Incorporating fruit and vegetable pomaces into staple foods like bread offers a promising strategy to enhance their nutritional value while simultaneously reducing waste and improving resource efficiency. The successful incorporation of POM, like other pomaces, into food products presents an additional technological challenge in maintaining consumer acceptability. POM contains up to ~90% (dry matter) total dietary fibre. Similar to other insoluble fibres, pomace has a high water absorption

capacity, leading to competition with gluten and starch for available moisture. Consequently, incorporating POM into bread formulations may result in insufficient hydration of these key structuring components, as observed with other insoluble fibers. In a recent study, we showed that incorporating just 5% POM into wheat dough doubled the total polyphenol content. Results also showed that co-formulating POM-containing breads with psyllium and pectin effectively counteracted the negative effects of apple pomace on water dynamics in wheat bread, significantly increasing dough and crumb hydration. Given the combined interactions between starch, dietary fiber and polyphenols, and the well-known health promising effects of polyphenol-impregnated fibers, such as POM material, the aim of this work was to study the bioaccesibility of polyphenols at subclass and individual compound levels in bread formulations and the effect of POM and co-formulated soluble fibers to modulate starch digestion (**Figure 1**). Polyphenol profiling was conducted using non-targeted screening and semi-quantification via LC-ESI-QTOF-MS/MS, and digestion was simulated using the standardized INFOGEST 2.0 *in vitro* protocol with pooled human saliva. Bread formulations included 100% wheat (W), or breads containing 5% psyllium (W:PSY) or 5% pectin (W:P), each with or without 5% POM. The analysis of polyphenol bioaccessibility in POM-containing bread, revealed distinct bioaccesibility patterns trends depending on the polyphenol subclass. Hydroxybenzoic acids (HBAs) and dihydrochalcones showed a marked increase in bioaccesibility from the oral (20-30%) to the intestinal phase (30-40%), whereas the bioaccesibility of hydroxycinnamic acids (HCAs) and flavonols remained low (<30%) across all the digestion phases, with bioaccesibility significantly declining in the intestinal phase. Flavanols (monomeric and oligomeric) remained undetectable in all phases. In general, the type of co-formulated soluble polysaccharide critically influenced polyphenol bioaccessibility, with psyllium promoting intestinal release of HBAs and dihydrochalcones while concurrently reducing the bioaccessibility of HCAs. In contrast, pectin consistently reduced the bioaccessibility of all polyphenol subclasses across all digestion phases, which limits polyphenol release but may favor colonic delivery. Interestingly, at individual compound level, psyllium induced increased bioaccessibility for several compounds during gastric and intestinal phases, but these did not cluster by core structure (chemical subclass), indicating that digestive behavior is governed by compound-specific structural features rather than broad class-level traits. In general, most individual polyphenols showed reduced bioaccessibility in the presence of either POM or soluble fibers. In terms of starch digestion, POM and the co-formulation of POM with soluble fiber significantly reduced starch digestibility, with the pectin-POM combination exhibiting the lowest extent of starch digestion.

Figure 1. Experimental design and conceptual workflow.



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[1085] Macadamia husk phenolic-loaded liposomes: *In vitro* digestibility and potential as yogurt-based delivery systems

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Background and purpose: Globally, macadamia nut production generates substantial amounts of by-products, particularly macadamia husk, which is rich in phenolic compounds known for their antioxidant and health promoting properties. This study aimed to encapsulate a phenolic-rich extract from macadamia green husk to protect their stability for food applications. Phenolic compounds are often unstable and susceptible to environmental conditions such as heat, light, enzymes and pH.

Experimental approach: New Zealand macadamia husk phenolic extract (MHPE) was encapsulated into liposomes using high shear mixing in aqueous media (pH 6.5) and subsequently, high-pressure homogenization (2000 MPa), aiming to improve the liposomes colloidal stability. The surface of anionic liposomes was coated with cationic chitosan (0.4%, w/v) to increase the physical stability of liposomal structure. The liposomes were incorporated into yogurt as a food carrier to enhance the bioavailability of macadamia husk phenolics. To evaluate the characteristics of liposomes, particle size, zeta potential (ζ-potential), polydispersity index (PDI), encapsulation efficiency (EE), and morphology were determined. The *in vitro* cytotoxicity study of non-encapsulated extract and the liposomes containing MHPE were also investigated using Caco-2 cells. *In vitro* bioaccessibility was evaluated by measuring total phenolic content release during simulated gastrointestinal digestion of liposomes alone or when incorporated into a low-fat yogurt.

Key results: Liposomes, whether empty or loaded with MHPE, exhibited nanoscale particle sizes, low polydispersity, and negative surface charge (ζ-potential). The mean diameters of empty and MHPE-loaded liposomes were approximately 112 nm and 77 nm, respectively. Chitosan coating significantly increased vesicle size (empty: 522 nm; loaded: 501 nm) and broadened the size distribution (PDI, 0.41). Uncoated liposomes were strongly anionic (−62.55 mV for empty; −43.11 mV for loaded), whereas chitosan coating reversed the surface charge to strongly positive values (+48.22 mV for empty; +49.99 mV for loaded), confirming successful adsorption of the cationic polymer. Transmission electron microscopy (TEM) showed that the vesicles were predominantly

spherical in morphology, and their observed sizes were consistent with the size measured by dynamic light scattering (DLS). Coated liposomes achieved higher EE (91.15%) compared to uncoated liposomes (81.50%). Furthermore, both free extract and MHPE-loaded liposomes exhibited no cytotoxicity in Caco-2 cells. Simulated digestion of fortified yogurt demonstrated that liposomal encapsulation provided substantial protection under gastric conditions (low pH) but lost membrane integrity under intestinal conditions, releasing phenolic compounds. Importantly, coated liposomes exhibited a slower release of phenolics compared to uncoated liposomes.

Conclusion: These findings support the potential utilisation of macadamia husk as a readily available and rich source of phenolics. Liposomal encapsulation of these phenolic offers an effective strategy to protect them from negative environment (gastrointestinal) conditions and to enhance their delivery and bioaccessibility through a yogurt product.

Keywords: Macadamia husk phenolics; Chitosan-coated liposomes; Encapsulation efficiency; *In vitro* digestibility; Bioaccessibility.

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[1087] Wet-type grinder-treated rice bran as a natural hydrocolloid alternative for improving gluten-free rice bread quality

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This study investigated the potential of wet-type grinder–treated rice bran (WG-RB) as a plant-derived hydrocolloid-like material for improving gluten-free rice bread. Rice bran, a nutrient-rich by-product of rice milling, is abundant in dietary fibers, proteins, and antioxidants but remains underutilized due to its coarse texture and poor dispersibility. To overcome these limitations, rice bran was physically modified using a wet-type grinder (WG), and the study clarified how WG-induced structural refinement enhances its functionality in rice-bread systems.

Rice bran powder (5% w/w) was processed using a Super Masscolloider through 1, 5, 10, and 15 passes (T1, T5, T10, T15). Particle size distribution, viscosity, dispersion stability, antioxidant activity, and bile acid–binding capacity were evaluated. Rice-flour bread containing 3% WG-RB was then prepared to assess fermentation behavior, batter rheology, specific volume, and crumb texture.

WG treatment substantially reduced particle size and markedly increased viscosity, resulting in improved dispersion stability—from rapid sedimentation within 20 min in untreated bran to 90% of the particles remaining suspended after 24 h in T15 WG-RB. Fermentation and rheological analyses demonstrated that WG-RB enhanced gas-holding capacity and increased batter viscoelasticity, with T15 showing the highest recovery rate (69%). Bread supplemented with T15 WG-RB showed a 53% increase in specific volume and a 73–76% reduction in crumb firmness compared with the control. Image and color analyses further revealed a finer, more uniform crumb structure and increased whiteness. Together, these results indicate that WG-induced microstructural refinement substantially improves the functional performance of rice bran within gluten-free rice-bread matrices.

These enhancements are a direct result of WG-induced micronization and physical modification of rice bran, which improve its viscosity and dispersion stability. These modified properties enable WG-RB to integrate more effectively into the rice-flour matrix, thereby enhancing batter structure, stability, and gas retention during proofing and baking. The findings elucidate how microstructural modification of rice bran improves rheological and technological properties in gluten-free systems. Overall, WG treatment is a key strategy for valorizing rice bran as a clean-label, sustainable hydrocolloid-like ingredient. This not only enhances product quality but also promotes resource utilization in gluten-free breadmaking, thereby contributing to sustainable food practices.

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[1092] Interactions of whey protein isolate and sodium caseinate with different kinds of mild preheating treatments

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We have presented about differences of the mixed gel from whey protein isolate and sodium caseinate in the presence of glucono-δ-lactone (GDL) with or without heat-treatment at the 16th IHC. In this time, we would like to mention about effects of mild preheat treatment of each protein on the property of mixed protein gel to clarify the roles of each protein in the mixed systems[1)].

Ultrasound spectroscopy and confocal laser scanning microscopy (CLSM) methods were developed to visualize of interaction between sodium caseinate (SC) and whey protein isolate (WPI) with mild pre heat-treatment (57°C, 10 min) followed by adding GDL. Ultrasonic velocity changes during incubation at 25°C after adding GDL for four kinds of mixtures (pre-heated SC plus pre-heated WPI, pre-heated SC plus no-treated WPI, no-treated SC plus pre-heated WPI and no-treated SC plus no-treated WPI) were

monitored. The changes in gradient of velocity of each mixture was characteristic with each other. These results suggest that the mild pre heat-treatments of the protein effect the timing of increase of compressibility of each system. CLSM observation with individualized dyes which has different maxima of exciting and emission wavelengths showed pre-heated SC plus no-treated WPI mixture has slightly coarse structure and the highest correlation coefficient which suggests the highest colocalization of the SC and WPI among the four kinds of mixed protein systems. Furthermore, the scanning electron microscopy (SEM) observation suggests that there are some differences among the gels, namely, pre-heated WPI leads the formation developed three-dimensional gel networks with filamentous structure from aggregated particles, whereas, SC promotes the formation of crowded networks like a cluster composed from more fine aggregated particles instead of developed filamentous structure. These results demonstrated that although SC is known as a heat-stable protein, pre-treated SC could lead to more increase of the collaboration with WPI in the presence of GDL, this finding expected a possibility to create a food material with new texture of in food using milk protein mixed system.

1) Colloids and Surfaces B: Biointerfaces 241 (2024) 114016

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1095 Physicochemical and Functional Properties of Wet-Type Grinder–Treated Vegetables as Natural Hydrocolloids

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This study evaluated wet-type grinder (WG)−treated vegetables as plant-based hydrocolloids for developing functional food aimed at preventing metabolic diseases. The aim was to clarify how WG-induced structural changes affect the physicochemical properties of vegetable fibers and how these modifications influence functional properties related to bile acid metabolism and starch digestion.

Seven vegetables, Ashitaba (AS), Okra (OK), Komatsuna (KO), Carrot (CA), Spinach (SP), Burdock (BU), and Broccoli (BR) were selected. Each vegetable powder (5% w/w) was processed with a Super Masscolloider for up to ten cycles, and samples were collected after 1 (T1), 3 (T3), 5 (T5), and 10 (T10) passes. Physicochemical properties were assessed by measuring particle size distribution, viscosity, and dispersion stability, while functional properties were evaluated based on bile acid–binding capacity and in vitro starch digestibility.

WG treatment markedly reduced particle size and increased viscosity, thereby improving dispersion behavior. Dispersion stability improved from visible sedimentation within 1 hour in untreated samples to 88–100% stability after 24 hours in T10 samples. Bile acid–binding capacity increased approximately twofold compared with cellulose controls (0.14 to 0.30–0.47 μmol/100 mg DM), whereas starch digestibility decreased from 80% to 77–57%, reflecting a greater proportion of slowly digestible starch. Correlation analysis revealed a strong positive relationship between viscosity and bile acid–binding capacity and a negative relationship with rapidly digestible starch (RDS). These findings indicate that higher viscosity enhances bile acid sequestration and attenuates starch hydrolysis.

These enhancements result from WG-induced micronization and morphological changes, which improve physicochemical properties and enhance functional performance. Overall, these findings indicate that WG treatment enhances not only the physicochemical properties of vegetable materials but also their functional properties, particularly those associated with bile acid metabolism and starch digestion. Through these physicochemical improvements, WG-treated vegetable fibers show promising potential as functional food ingredients that may support healthier lipid handling and postprandial glucose responses.

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[1099] Surface-Mediated Enzymatic Reactions of Banana Starches: Quantifying Amylase Interaction and Inhibition Effect

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Understanding the enzymatic reactivity of starch-based materials is essential to optimizing their functional properties and evaluating it in raw materials characteristics. This study investigates the interaction between banana starch and amylase, focusing on catalytic conversion of the substrate by the enzyme with kinetics and inhibition mechanisms. Starch hydrolysis by amylase involves a multistep process beginning with enzyme adsorption onto the starch surface, followed by catalysis that yields products such as maltose and oligosaccharides, evaluated as maltose equivalents. Digestibility assays used to quantify the carbohydrate composition of banana starches indicated significant levels of resistant starch (RS) and insoluble dietary fiber (IDF), components known to influence enzymatic accessibility and reactivity. To better understand the chemical surface properties of the starch granules, their properties were quantified using techniques such as inverse gas chromatography (iGC) and X-ray photoelectron spectroscopy (XPS). Kinetic evaluation using initial reaction rates revealed the presence of inhibitory effects. These findings indicate that enzymatic activity is inhibited by substrate or product, with additional contributions potentially arising from endogenous compounds in the raw materials. Overall, enzyme kinetics elucidated the inhibitory phenomena governing amylase and starch interactions, contributing to a deeper understanding of how material composition and surface properties regulate enzymatic hydrolysis, and the catalytic effect. This study provides mechanistic insights into the enzymatic degradation of native starch granules, elucidating the interplay between granular structure and reactivity. It further emphasizes the critical role of combining detailed surface characterization with quantitative enzymatic assays to accurately predict starch functionality in both formulation design and in vitro digestion modeling.

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[1103] Effect of chao- and kosmotropic natural deep eutectic solvents on the chitin separation and from *H. Illucens* pupae molt shells

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Chitin has recently been finding novel applications in the food industry, such as antimicrobial agent in packaging, flavor enhancer, and emulsifier, and its intake as bioactive compound has show to have potential benefits in gut health, e.g., controlled lipid intake, anti inflammatory agent, and even reduced cancer risk. At the same time, deep eutectic solvents (DES) have recently gained notoriety as a green media for chitin isolation and purification, with different solvents demonstrating varying degrees of success in protein removal. Depending on the nature of its components, DES can exhibit both chao- and kosmotropic effects, with the former being leveraged to remove protein from chitin biomass. While considerable research exists on the nature and effects chao- and kosmotropic ions, little research has been done to understand the contribution of such molecules when working in tandem in DES. Herein we explore the effect seven different combinations of hydrogen bond acceptor (HBA) and donor (HBD) moieties with varying degrees of both chao- and kosmotropic properties on the separation of chitin and protein from black soldier fly (Hermetia illuciens) molt shells from their pupae stage. Samples were characterized via Fourier-transform infrared spectroscopy (FTIR), thermogravimetric analysis (TGA), confocal laser microscopy (CLSM), scanning electron microscopy (SEM), while protein content was determined through enzymatic hydrolysis. FTIR analysis showed that chaotropic DESs e.g., guanidine/urea and guanidine/lactic acid resulted in lower amide/hemiacetal ratios when compared to starting insect biomass, suggesting effective removal of protein fraction, while kosmotropic DESs, e.g., choline citrate/glycerol, had very little effect on this ratio.

However, both groups of DES still showed a larger protein fraction than chemically treated chitin. Interestingly, protein estimation via N_2 analysis of the protein hydrolysate, resulted in very low protein content for all DES. i.e., almost no protein was present in treated samples. This discrepancy between FTIR suggests that not all protein could be enzymatically removed. TGA analysis revealed that, for samples treated with more chaotropic solvents, this protein loss was indeed related to protein removal, as observed in the area reduction related to protein degradation. However, samples treated with kosmotropic DES presented three different degradation curves, related to chitin, protein-chitin, and protein. Confocal microscopy corroborated these results, showing protein intertwined with chitin fibers in samples treated with kosmotropic DESs. These results suggest that the kosmotropic-heavy DES led to protein-chitin reassembly or crosslinking, rather than separation, leading to underestimation of protein content from common analytical techniques.

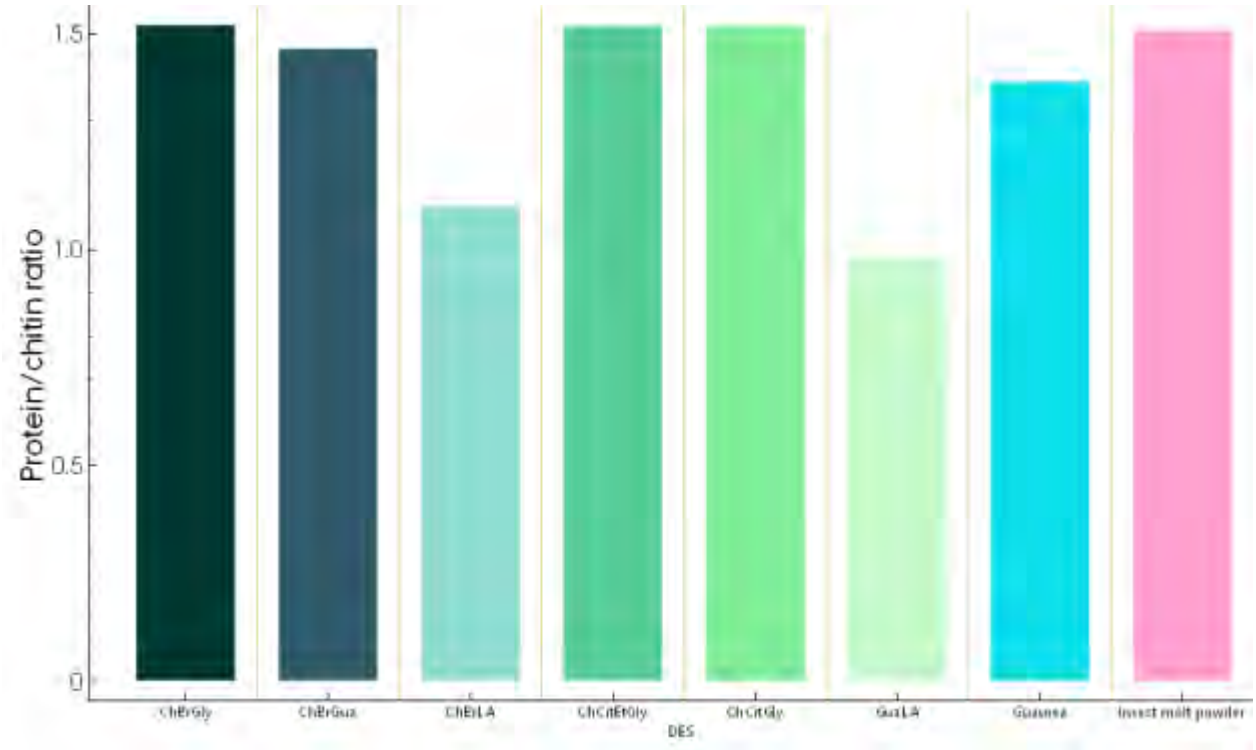

Figure 1 Protein/chitin ratio of treated insect samples in DES.

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[1112] High-yield and scalable preparation of lignin nanoparticles with uniform surface properties for stable Pickering emulsions

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Emulsions are widely used in food, pharmaceutical, and cosmetic products, where stabilizers are essential to prevent phase separation and ensure long-term stability. Most conventional stabilizers are synthetic surfactants derived from fossil resources, raising environmental and health concerns and highlighting the need for sustainable alternatives. Lignin, an abundant byproduct of the pulp industry, shows strong potential as a natural stabilizer. Converting lignin into lignin nanoparticles (LNPs) greatly improves its dispersibility and surface activity, enabling their use as Pickering stabilizers. In this study, we developed a green, high-yield, and scalable anti-solvent precipitation method to produce LNPs with reproducible performance. The solvents are fully recyclable, and the resulting nanoparticles can be redispersed in water through sonication.

We systematically investigated how the initial lignin concentration influences LNPs characteristics and their ability to stabilize emulsions. The size and morphology of the LNPs were analyzed using dynamic light scattering (DLS), transmission electron

microscopy (TEM), and asymmetric flow field-flow fractionation coupled with multi-angle light scattering (AF4–MALS). Their interfacial properties were evaluated through contact angle measurements and dynamic interfacial tension analysis. By increasing the initial lignin concentration, LNPs with hydrodynamic diameters ranging from 100 to 370 nm were obtained. These nanoparticles showed strong interfacial activity, readily adsorbing at the oil–water interface and reducing interfacial tension. When used as stabilizers in Pickering emulsions, the LNPs produced uniform droplet sizes and highly stable emulsions. Interestingly, LNPs of different sizes exhibited similar stabilizing performance. Combined AF4–MALS, TEM, and atomic force microscopy (AFM) analyses suggest that a portion of the LNPs undergoes partial deformation during ultrasonication, generating smaller fractions that contribute to emulsion stabilization.

Overall, this work demonstrates a scalable and sustainable route for producing LNPs with stable, size-independent surface properties, enabling reliable performance in Pickering emulsions. The findings provide valuable insight into designing reproducible, bio-based colloidal stabilizers and support the broader development of eco-friendly emulsions.

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[1115] Acorn flour enriched bread: *in vitro* starch digestion and colonic fermentation

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Quercus spp. fruits (acorns) have been traditionally used as animal feed, but their nutritional quality linked to their carbohydrate, fiber, fat and phytochemical contents has raised interest in including acorns in the human diet.

This study aimed to investigate the digestibility of starch and the metabolic fate of hydrolysable tannins in newly designed acorn-containing breads, using static *in vitro* gastrointestinal digestion and colonic fermentation models.

Acorn-based breads were prepared including different percentages of acorn flour (0%, 20%, 30%, 40%, respectively) using a sourdough fermentation process. Breads were subjected to *in vitro* gastrointestinal digestion, and rapidly (RDS) and slowly digestible starch (SDS) fractions were determined by measuring glucose release after 20 minutes and 120 minutes of intestinal incubation. Digested samples were then centrifuged, and the supernatants analyzed by UHPLC-MS/MS to determine the (poly)phenols' bioaccessible fraction. The residual pellet, representing the undigested portion of the breads, was subjected to 48-hour static *in vitro* colonic fermentation. Fermented samples were extracted and analyzed to elucidate the catabolic pathway of (poly)phenols.

The inclusion of acorn flour into bread led to an increase of SDS and a decrease of RDS per 100 g of product, according to the increasing acorn flour content. A similar inverse relationship between SDS and RDS was observed when RDS and SDS were refereed to available starch in bread. The relevant content of SDS (≥ 40% of SDS/Av. starch) quantified in the samples, highlighted the potential impact of bread consumption in reducing post-prandial glycaemic response *in vivo*. After *in vitro* digestion, only a limited fraction of native compounds were quantified in the digested sample, suggesting a low bioaccessibility of (poly)phenols in the upper gastro-intestinal tract. On the contrary, during *in vitro* colonic fermentation, native tannins were degraded by the gut

microbiota into ellagic acid, urolithins and low molecular weight catabolites. A total of 8 new formed-microbial catabolites (6 urolithins, 3 benzoic acids and 1 benzene derivative) were detected. The main catabolites resulted 3,8,9,10-tetrahydroxyurolithin (Uro M6), 3,8,9-trihydroxyurolithin (Uro C), derived from ellagitannin metabolism, and 1,2,3-trihydroxybenzene, derived mainly from gallotannin metabolism. Their concentration gradually increased over the incubation period with a peak at 24-hour incubation.

These findings support the inclusion of acorn flour in daily consumed cereal-based foods, as it represents a valuable source of high-quality carbohydrates and bioavailable (poly)phenols. However, these results should be confirmed through *in vivo* studies.

This study received funding from the European Union - Next-GenerationEU - National Recovery and Resilience Plan (NRRP) – MISSION 4 COMPONENT 2, INVESTMENT N. 1.1, CALL PRIN 2022 PNRR D.D. 1409 del 14-09-22– (AcorN: a forgotten resource to be rediscOVered and valorizEd in the production of good and heaLThY foods. "NOVELTY") CUP N. J53D23018470001.

Return to program.

[1117] Textural engineering of analog rice using sago and fermented kidney bean flour hydrocolloids

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The development of analog rice offers a promising strategy to enhance the nutritional value of staple foods in regions where rice is a major carbohydrate source. Because consumer acceptance depends strongly on texture, understanding how composite ingredients interact as a hydrocolloid matrix is essential for engineering analog rice with desirable physical and structural characteristics. This study examined how a composite system of sago starch, fermented kidney bean flour (FKBF), and modified cassava flour (Mocaf) contributes to textural formation and microstructural integrity. The objective was to determine how variations in the sago-to-FKBF ratio influence the functional properties of the hydrocolloid matrix, with Mocaf fixed at 20%.

Five formulations were prepared with sago-to-FKBF ratios of 30:50 (F1), 35:45 (F2), 40:40 (F3), 45:35 (F4), and 50:30 (F5). Texture Profile Analysis (TPA) quantified hardness, springiness, cohesiveness, gumminess, and chewiness in cooked analog rice. Scanning Electron Microscopy (SEM) characterized starch granule behavior and structural uniformity, enabling evaluation of structure–function relationships governing texture.

The sago–FKBF ratio was the principal factor influencing physical performance. Sago-rich formulations (F4 and F5) exhibited greater hardness, elasticity, and structural strength. F5 showed the highest hardness (355.90 ± 14.39 g) and strong springiness (3.63 mm), reflecting the gelling characteristics of amylopectin-rich sago starch, which forms a cohesive and elastic matrix during gelatinization. The compact network created by sago enhanced mechanical stability and mouthfeel. In contrast, higher FKBF content disrupted starch network formation. SEM revealed porous, discontinuous structures with cavities and weak granule fusion. Proteins and fibers in FKBF likely competed with starch for water, limiting swelling and reducing gel strength.

This study demonstrates that the physical properties of analog rice can be predictably tuned by adjusting the hydrocolloid composition of the flour blend. A sago-dominant system promotes formation of a robust gelatinized network essential for achieving rice-like texture, whereas excessive FKBF weakens structural integrity. These findings provide a practical framework for improving analog rice and highlight the importance of starch-rich components for creating fortified staple foods that meet consumer expectations.

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[1131] Effects of Cowpea Protein Isolates and Stearic Acid on the Physio-chemical and In Vitro Starch Digestibility of High Amylose Maize Starch

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Starch, lipids, and proteins are the three primary macronutrients in the human diet, providing the main source of energy. These macronutrients exist in many food systems, such as starchy foods, and they may undergo some interaction to alter texture, flavour, nutrition and other properties of starch. Cooked starch is susceptible to rapid digestion by digestive enzymes in the body, leading to postprandial hyperglycemia. Amylose-lipid complexes and amylose-protein interactions have been shown to affect the physicochemical properties of starch, reducing the amount of rapidly digestible starch and increasing the amount of resistant starch. This study aims to investigate the possible formation of ternary complexes between stearic acid (SA), cowpea protein isolates (CPI) and high amylose maize starch (HAMS) and their effect on physiochemical properties of HAMS and in vitro starch digestibility (IVSD). Stearic acid (1.5 and 3% wt.) and protein (10 and 15% wt.) were pasted with HAMS for a short time (30 minutes) and an extended time (2 hours). The paste was freeze-dried and characterised by X-ray diffraction (XRD), differential scanning calorimetry (DSC) and IVSD (Figure 1). The addition of SA and CPI to HAMS resulted in a prominent peak viscosity during cooling that was not observed in the control, suggesting the formation of ternary complexes (starch-lipid-protein). The DSC and XRD results confirmed that the addition of SA resulted in the formation of a V-type complex, and the latter was affected by CPI. The IVSD results (Figure 1) showed that the SA alone and CPI alone with HAMS reduced rapidly digestible starch (RDS), estimated glycemic index (eGI) and increased the amount of resistant starch (RS) compared to the HAMS. The combination of both SA and CPI further reduced RDS, eGI and increased RS compared to HAMS, which contains SA alone and CPI. This further suggests the formation of a ternary complex (starch-lipid-protein) that leads to HAMS, which was less susceptible to

digestible enzymes, thus having a lower glycemic index and higher resistant starch content. These ternary complexes between HAMS, CPI and SA may be used as a food-grade ingredient in starchy foods to reduce digestibility and can reduce postprandial hyperglycemia. However, In Vivo digestibility studies may be necessary to ascertain the effect of ternary complexes on the digestibility of HAMS.

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1136 Sol-gel like transition of semi-dilute suspension of rod-like cellulose nanoparticles

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Cellulose nanocrystals (CNCs) are rod-like nanoparticles derived from renewable biomass and have recently gained attention as sustainable hydrocolloids for food and functional material applications. Achieving sol–gel transition and viscoelastic control even at lower solid contents would expand their potential for environmentally friendly formulation design.

In this study, electrophoretic mobility was measured to examine the charging behavior of CNC particles under various pH and electrolyte conditions. Furthermore, we systematically investigated how electrolyte concentration, particle concentration, and resting time influence the sol–gel state of semi-dilute aqueous CNC suspensions.

Gelation behavior was evaluated by a simple vial inversion test, and viscoelastic properties were characterized using small- and large-amplitude oscillatory shear measurements.

The electrophoretic mobility results showed that CNC particles retained a negative charge nearly independent of pH, indicating stable surface potential and electrostatic repulsion over a wide pH range. Gelation occurred within a limited window of electrolyte concentrations and became more pronounced with increasing CNC concentration and resting time. The appearance of a finite elastic modulus confirmed the formation of a gel network. The dependence on electrolyte concentration suggests that orientation-dependent aggregation among charged rod-like particles governs the network structure. These findings provide fundamental insights into the design of sustainable, bio-based hydrocolloid gels with tunable mechanical properties.

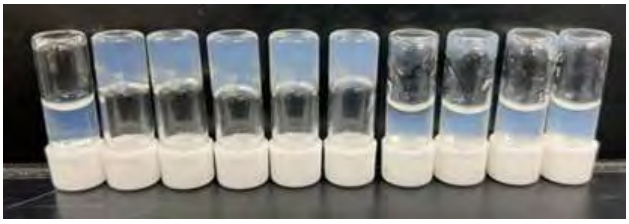

Figure 1. Sol-gel states of CNC suspensions. The concentration of salt increases from left to right.

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1138 Effects of debranching and ultrasound treatment on starch nanoparticles fabrication: a structure-functional analysis

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Starch nanoparticles (SNPs) are innovative food hydrocolloids with improved functionalities for enhancing food texture and nutrition. This study investigates the sequential treatment of pullulanase and ultrasound to produce SNPs from cassava and faba bean starch. First, an optimisation of pullulanase enzyme modification was performed using Response Surface Methodology (RSM) with a Box-Behnken Design (BBD). Then, three processing sequences were compared, including (1) enzyme only, (2) pre-treatment ultrasound followed by enzyme, and (3) enzyme followed by post-treatment ultrasound. RSM-BBD identified optimal conditions for processing 3% starch with 75 U/g enzyme and a 10 h incubation time, which successfully produced SNPs. Sequential enzymatic treatment followed by post-treatment ultrasound yielded the smallest and uniform nanoparticles (cassava: PSD = 134 nm, PDI = 0.220; and faba bean: PSD = 208.7 nm, PDI = 0.451). Size exclusion chromatography results demonstrated a significant molecular weight reduction from the native form (cassava: 1.2×10^7 g/mol, and faba bean: 4.8×10^7 g/mol) to the enzymatic (cassava: 4.7×10^3 g/mol, and faba bean: 6.8×10^3 g/mol), with the most reduction observed in the sequential enzymatic and post-treatment ultrasound (cassava: 4.1×10^3 g/mol, and faba bean: 5.1×10^3 g/mol). Structurally, the sequential enzymatic ultrasound treatment allowed structural re-organisation. From X-ray diffraction, the formation of a V-type crystalline pattern was observed, followed by a significant increase in relative crystallinity (cassava: 37.9% to 59.6%, and faba bean: 41.5% to 53.1%). Fourier-transform infrared and nuclear magnetic resonance analyses confirmed an increase in short-range structural order, indicating reorganisation toward a more ordered starch structure. Functionally, all enzymatically treated samples developed unique semisolid-forming capabilities at room temperature and a low starch concentration of 3%, representing a novel cold-set gelation mechanism distinct from conventional heat-induced starch gelation. Ongoing rheological characterisation will provide more comprehensive insights into the rheological properties, while digestibility profiles indicated an increase in resistant starch content, supporting applications in semi-solid food systems for better glycemic level management. This research provides a clear mechanistic insight into how enzymatic and ultrasound methods can be utilised to enable the fabrication of innovative food hydrocolloids with improved nutritional and functional properties.

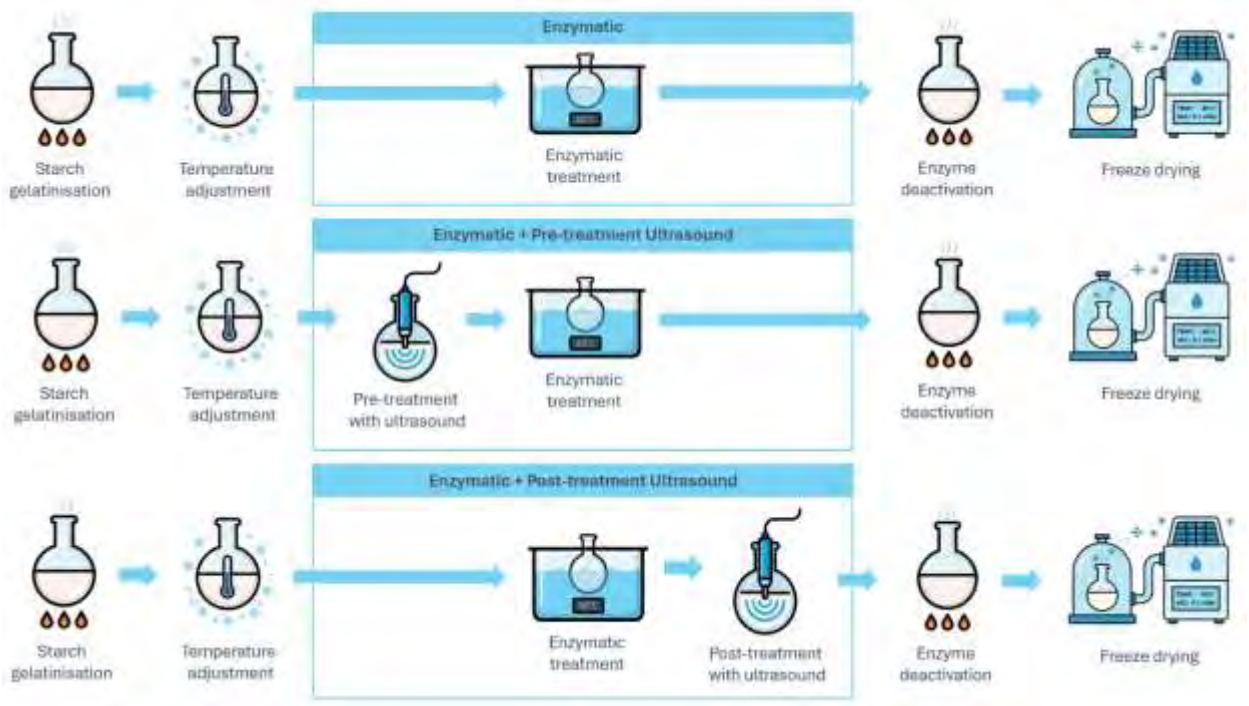

Figure 1. Schematic representation of three processing sequences of: (1) enzyme only, (2) pre-treatment ultrasound followed by enzyme, and (3) enzyme followed by post-treatment ultrasound.

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[1142] Selective detoxification of digesta revealed how apple pomace modulate transepithelial glucose transport and stimulate GLP-1 secretion

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Achieving glucose-lowering and appetite-suppressing effects through dietary strategies depends not only on the presence of active compounds but also on the timing and rate of nutrient release from the food matrix. This highlights the need for mechanistic research employing physiologically relevant models that accurately mimic the environment experienced by intestinal epithelial and enteroendocrine cells in the body. In this study, we hypothesised that whole apples and pomace (a by-product from juice/cider processing with hydrocolloid properties), offer dual but distinct cardiometabolic benefits by modulating glucose homeostasis and appetite regulation. To test this hypothesis, physiologically relevant *in vitro* digesta from whole apple and apple pomace were prepared using the upper gastrointestinal INFOGEST protocol coupled to a novel laboratory-implementable solubilization and purification method that doubled polyphenol concentrations without inducing cytotoxicity. These purified digesta were incubated with differentiated Caco-2 cell monolayers and with STC-1 enteroendocrine cells. Samples collected at the end of the gastric and intestinal phases represented pre- and post-intestinal chyme. By concentrating bioaccessible polyphenols and removing cytotoxic constituents from digesta, the resulting digesta from whole apple and apple pomace (mostly consisting of cell walls impregnated with polyphenols) were suitable for both mass spectrometry analysis and direct application to Caco-2 and STC-1 cells. This integrated approach enabled mechanistic investigation of physiologically relevant bolus and chyme.

LC-ESI-QTOF-MS/MS analysis of 48 polyphenols across apical, intracellular, and basolateral compartments showed predominant apical retention, except for flavanols. Whole apple and pomace significantly inhibited glucose transport, primarily driven by dihydrochalcones and hydroxybenzoic acids (Spearman $\rho>0.70$). Notably, although phloridzin alone inhibited GLP-1 secretion, gastric digestates of both apple and pomace enhanced secretion by 50%. However, only the pomace digestate retained this effect after intestinal digestion, increasing GLP-1 levels by 250% compared to the control.

Although both apples and their by-product pomace may offer cardiometabolic protection, the mechanisms appear to differ due to variations in polyphenol profiles and bioaccessibility (**Figure 1**). Whole apple digesta strongly inhibited transepithelial

glucose transport in both pre- and post-intestinal chyme, suggesting persistent activity throughout the upper gastrointestinal tract. In contrast, pomace showed moderate glucose transport inhibition at the gastric phase, which was lost after intestinal digestion. However, while both apple and pomace gastric digesta stimulated GLP-1 secretion, only pomace retained this effect following intestinal digestion - highlighting its unique potential as a functional ingredient for appetite suppression and lowering food intake.

The distinct mechanisms by which whole apple and apple pomace exert glucose-lowering and appetite-suppressing effects, respectively, underscore the need for greater precision in evaluating how specific food components influence physiological responses. These findings support a shift toward more targeted nutritional strategies, moving beyond generalized dietary recommendations to leverage the unique functional properties of individual food matrices with hydrocolloid properties. They also highlight the vast, largely untapped complexity of food systems as a resource for designing tailored interventions to prevent chronic diseases.

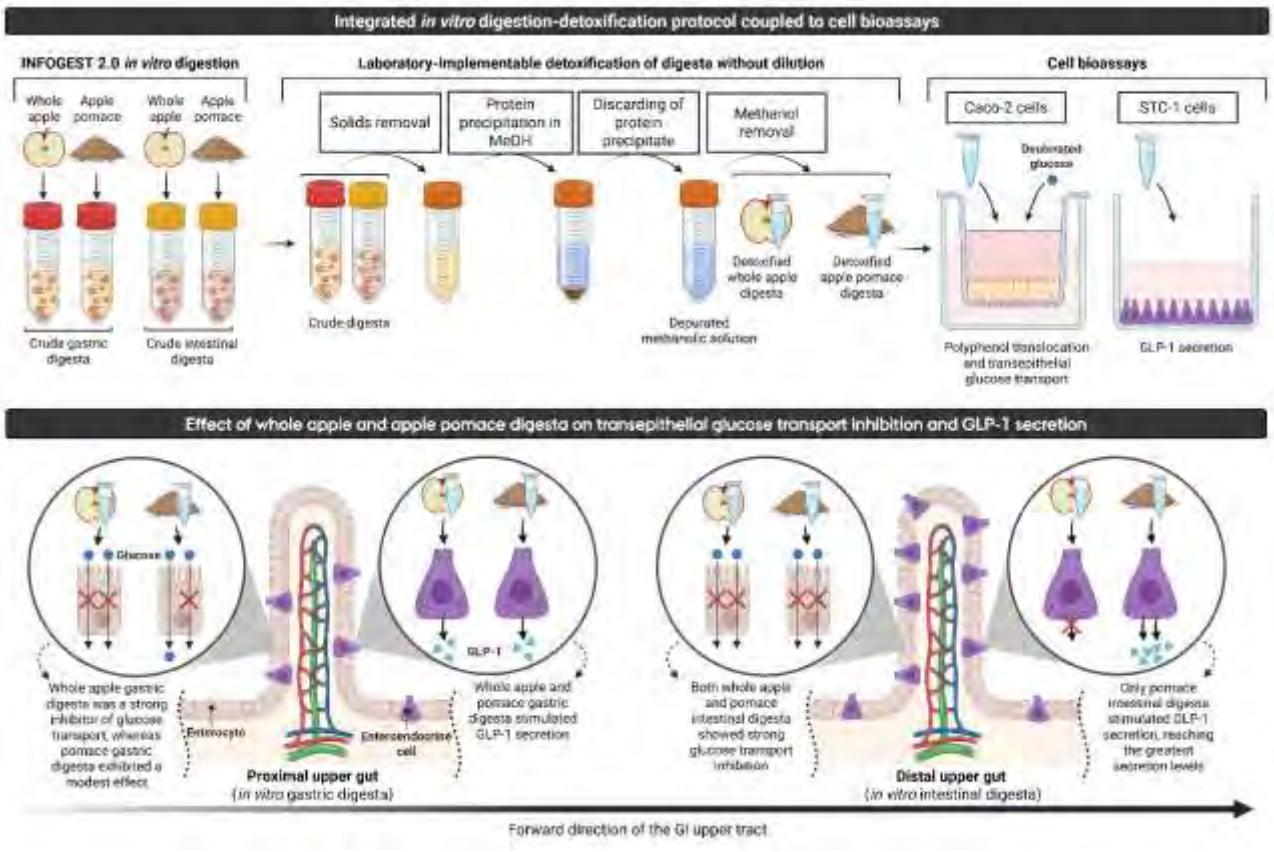

Figure 1. Depiction of the integrated *in vitro* digestion-detoxification protocol used before cell bioassays to reduce the presence of potentially toxic proteins and insoluble

compounds that may affect cell survival, while concentrating the released polyphenols (top). Effect of whole apple and apple pomace detoxified digesta on transepithelial glucose transport inhibition and GLP-1 secretion (bottom).

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[1143] Evaluation of okra pectin as an alternative emulsifier in milk chocolate: Effects on rheological, textural and sensory properties

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Okra (*Abelmoschus esculentus*) pectin is a potential new source of natural polysaccharide with gelling and emulsifying capabilities, which can be exploited industrially as functional ingredients in food and non-food products. This study evaluated the potential of okra pectin as a substitute for lecithin, an allergenic and increasingly costly emulsifier used in milk chocolate production. Milk chocolate samples were formulated with 0.2% okra pectin, with 0.2% lecithin serving as the positive control. Rheological profiling (at 35 °C and 60 °C), texture analysis, and consumer sensory evaluation were conducted to determine the impact of incorporating okra pectin. All formulations exhibited shear-thinning flow behaviour however, chocolates containing okra pectin showed significantly higher viscosity values across measured shear rates compared with lecithin based controls. Texture profile analysis revealed significant

differences in gumminess and cohesiveness, while hardness, springiness, and other parameters remained comparable. Sensory difference testing indicated that consumers detected only minor attribute variations and overall acceptability did not differ significantly between samples. The results demonstrate that okra pectin can function effectively as a chocolate emulsifier, producing milk chocolate with rheological, textural and sensory characteristics comparable to those obtained with lecithin. These findings highlight okra pectin as a promising plant based hydrocolloid for chocolate manufacturing, acceptable to consumers, offering both functional and allergen avoidance advantages.

Return to program.

[1145] Influence of thermal processing on extraction efficiency and properties of tamarind xyloglucans

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Tamarind (*Tamarindus indica* L.) seed kernel polysaccharide (TSKP), a xyloglucan-rich biopolymer, is gaining prominence for its functional relevance in food and industrial hydrocolloid applications. This study investigated the impact of thermal processing conditions on the extraction efficiency, structural properties, and functional performance of TSKP. Thermal treatment significantly influenced extraction behaviour ($p < 0.05$), producing measurable differences in shelling efficiency, moisture content, pasting properties, and colour development. Optimal shelling efficiency (54.2–58.3%) was achieved at 180–210 °C, indicating an effective balance between thermal energy input and kernel separation. Moisture content ranged from 3.51 to 6.93%, demonstrating the

sensitivity of heat–moisture interactions. Peak viscosity values (2969–5378 cP) indicated thermally induced modifications to the polysaccharide matrix, while progressive colour development was attributed to Maillard and caramelization reactions. FTIR spectra under optimal processing conditions (210 °C, 25 min) showed characteristic polysaccharide absorption bands at 3329.6, 2918.6, and 895.1 cm^{-1}. Similarly, ^1H NMR resonances at δ 3.20–4.20 and 5.20–5.50 ppm confirmed the purity and molecular identity of the extracted xyloglucans. Moderate thermal conditions yielded polysaccharides with enhanced functional properties, including a high water-binding capacity (480–757%) and swelling power (250–857%). The findings demonstrate that controlled thermal processing can be used to optimize xyloglucan extraction while preserving desirable structural and techno-functional properties, supporting the development of high-performance hydrocolloids for food and related applications.

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[1147] Optimum compositions for shear-induced gel formation in model colloid-polymer systems

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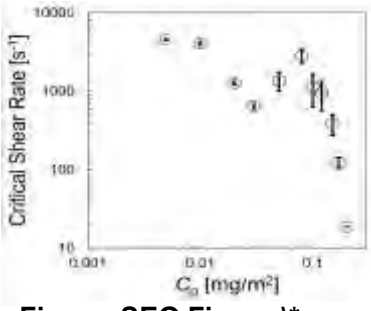
The rheological properties of colloidal suspensions and polymer solutions govern key operations in food processing (mixing, pumping) and determine the texture and swallowability of final products. In recent years, shear-induced gels (also known as shake-gels), which exhibit a fluid-like sol state at rest but transform into a non-flowable

gel state under shear, have attracted attention as hydrocolloids whose rheological properties change reversibly in response to external flow. The shake-gels consist of mixtures of high molecular weight polymers and adsorptive nanoparticles. This mechanism is considered to originate from deformation of polymer chains in the flow field and the network formation mediated by transient polymer–particle bonds. Such behavior may provide a new strategy for controlling the rheological properties of suspensions according to shear history. However, the detailed mechanism of shake-gel formation remains unclear, and the conditions that promote gelation have not yet been fully understood.

In this study, we investigated the variation in the onset shear rate of shear-induced gelation under flow. As a representative model system for shear-induced gels, aqueous mixed suspensions composed of silica nanoparticles and poly(ethylene oxide) (PEO) were employed. Particular attention was paid to the polymer dosage per unit particle surface area denoted as C_p. Using a cone–plate viscometer, steady shear was applied to the suspensions initially in the sol state, and the critical shear rate at which shear thickening and subsequent gelation occurred was systematically determined.

The results revealed that the critical shear rate strongly depended on C_p. Specifically, shear-induced gelation was most readily triggered at an intermediate C_p, whereas it was suppressed at higher C_p. This result can be explained as follows: when C_p was too low, polymer chains were insufficient to bridge particles, making network formation difficult. Conversely, at higher C_p, polymer saturation on particle surfaces inhibited interparticle bridging. At much higher C_p, the critical shear rate decreased again, likely due to enhanced polymer chain overlap and entanglement under flow.



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These findings suggest that both the balance between polymer adsorption and interparticle bridging and the flow-induced conformational response of polymer chains are key factors governing the onset of shear-induced gelation.

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[1150] Influence of ultrasound treatment on the emulsifying properties of *Tenebrio molitor*-based ingredients displaying different protein content

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This study investigated the influence of protein extraction steps and ultrasound (US) treatment on the structural and emulsifying properties of *Tenebrio molitor* protein-based ingredients displaying different protein contents. A mealworm defatted flour (MDF) and a mealworm protein isolate (MPI) were produced through defatting and alkaline solubilization, followed by isoelectric precipitation, respectively. Proximate composition revealed a significant increase in protein concentration from MDF (56.86 ± 0.68 %) to MPI (87.74 ± 3.64 %), although the protein extraction yield decreased from 87.41 % (MDF vs. initial flour) to 13.60 % (MPI vs. MDF). MPI exhibited a smaller particle size, higher solubility, and greater surface hydrophobicity and intrinsic fluorescence than MDF, indicating structural rearrangements that enhanced interfacial activity. Ultrasound (US) treatment induced conformational modifications in protein structure, increasing surface hydrophobicity without altering molecular weight distribution. Emulsions stabilized with MPI displayed smaller droplet sizes, higher ζ-potential values, and superior physical stability compared to MDF-based emulsions. Although US treatment did not affect the macroscopic properties of MPI emulsions, it improved the stability of MDF emulsions, suggesting enhanced interfacial adsorption and droplet stabilization.

US treatment did not compromise the emulsifying properties of MPI despite the structural changes induced, while it enhanced the functionality of MDF, highlighting ultrasound as a promising and sustainable approach to improve the techno-functional performance of insect-based protein ingredients.

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[1156] Bio-impact reformulation of “Caldo verde” soup with microalgae incorporation

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The use of natural sources of ingredients to develop functional foods with sustainable components has become a key focus in the food industry. Among these, marine resources - especially microalgae and seaweeds - stand out as promising options. Their high levels of proteins, fatty acids, minerals, fiber and other essential nutrients make algae increasingly popular in human diets around the world, offering noteworthy potential health benefits[1,2,3].

This study develops a more nutritious and convenient version of *Caldo Verde* soup by replacing cabbage with micro- and macroalgae. Three algae were tested: *Chlorella vulgaris* (spray-dried) and the seaweeds *Ulva rigida* and *Alaria esculenta*. They were added to the soup at different ratios. The base recipe used water, cauliflower, leek, onion, garlic powder, pepper, and olive oil. Formulations included 1% *U. rigida* (UrTw) or *A. esculenta* (AeTw); combinations of 0.5% seaweed with 1% or 2% *C. vulgaris* (UrTwCv1, UrTwCv2, AeTwCv1, AeTwCv2); and each seaweed with 0.5% *C. vulgaris* (UrwCv, AewCv). The soups were heated to 100 °C for 40 minutes and analyzed for physicochemical and nutritional parameters. Adding algae increased nutritional value - particularly proteins, lipids, minerals and phenolics. The 2% *C. vulgaris* formulations (UrTwCv2 and AeTwCv2) had the highest nutrient levels and qualified as sources of iron and/or manganese, while *A. esculenta* significantly boosted phenolic content. Overall, both microalgae and macroalgae improved nutritional quality; however, the control soup

showed higher in vitro digestibility (~64%) than the algae-enriched versions (~45%), indicating easier breakdown during digestion.

A PCA showed that the first two components explained 93.34% of the variance, linking nutritional composition to consumer acceptance. Soups with macroalgae were more appreciated despite lower nutritional values, whereas microalgae-enriched samples were nutritionally superior but less liked. This highlights a trade-off: microalgae improve nutrition but may reduce consumer appeal.

KEYWORDS

Functional foods, microalgae, macroalgae, nutritional profile, soups, bioaccessibility

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[1157] Exploration of electrospinning technique for producing food-grade nanofibers from legume protein concentrates and pullulan

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Electrospinning has recently gained increasing attention as a novel technique for producing polymer nanofibers for various application. Particularly within the food industry, these nanoscale fibrils have shown promising potential as structural building blocks in development of plant-based meat analogies, aiming to replicate the fibrous texture of conventional meat. Electrospun nanofibers has been produced using plant-based proteins like zein and soy, however, the use of non-food grade reagents and toxic organic solvents has significantly limited their applicability in food products.

In this study, soluble protein factions were first extracted from three commercial legume protein ingredients. Food-grade pullulan was incorporated at a protein-to-pullulan ratio of 50:12(w/w) to enhance solution viscosity and optimize surface tension and conductivity for electrospinning. Nanofibers were successfully produced using an applied voltage of 24 kV and a flow rate of 0.3mL/h. The resulting nanofibers were subsequently characterized in terms of their structural features, physicochemical properties, and nutritional composition. Key parameters investigated included protein-protein interactions, sulfhydryl content, surface hydrophilicity, secondary structure, thermal stability, protein solubility, and amino acid profiles.

The results revealed that electrospinning altered the structural arrangement of the protein-pullulan blends. Proteins with more disordered conformations tended to form more robust nanofibers. Denaturation and aggregation of proteins were observed, accompanied by the formation of new interactions between protein and pullulan. These structural modifications contributed to enhanced thermal stability. Moreover, changes in protein profiles indicated the formation of larger molecular weight protein complexes.

While the total protein content remained largely unaffected, electrospinning significantly influenced the amino acid composition.

To the best of our knowledge, this is the first study to successfully produce edible nanofibers from legume proteins and pullulan without using any harmful chemicals. Future research will focus on evaluating the impact of these nanofibers on the structure and functionality of texturized vegetable proteins for application in meat analogues.

Return to program.

[1159] Evaluation of polysaccharides from Malvaceae as sustainable excipients for sustained-release oral tablets

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Polysaccharides continue to attract interest as renewable and biodegradable alternatives to conventional semi synthetic tableting excipients in sustained release tablets. Building upon previous investigations on polysaccharides extracted from the Malvaceae family, this study focuses on a polysaccharide extracted from Baobab fruit as a potential sustainable tableting excipient. Polysaccharides were extracted from Nigerian baobab fruit pulp by hot water extraction at pH6 and ethanol precipitation. The extracted baobab polysaccharide (BP) consisted of predominantly linear xylogalacturonans (containing between ~30-40% galacturonic acid) and significant proportions of neutral sugars. Comparable uronic acid contents are reported for other polysaccharides from the Malvaceae family investigated as tableting excipients, such as okra (47–57 %) [1] and grewia gum (19–35%) [2], suggesting broad compositional similarities but notable differences in ratios of neutral to acidic monosaccharides.

The amorphous BP powder was characterised and compacted into tablets with microcrystalline cellulose and theophylline as a model drug. An increase in BP concentration (from 10% to 57.5%) enhanced the tablets' mechanical strength and reduced their porosity (from 11% to 9%). Dissolution studies revealed pH dependent release. At pH 1.2, tablets with a higher BP content (30–57.5%) demonstrated sustained release over a 4h period. Conversely, at pH 6.8, increasing the BP content promoted a burst release. This behaviour of strong acid stability and erosion dominated release at higher pH, is likely controlled by BP's xylogalacturonan rich, weakly acidic structure, which forms a gel in acidic media and rapidly erodes in a basic environment. This performance places BP in an interesting position relative to other Malvaceae polysaccharides. Grewia gum produces hard compacts and maintains sustained release in both acidic and neutral media [3] and okra polysaccharides, with their higher uronic acid content, typically form a stable swollen gel on the tablet surface that slows drug release [4].

Overall, these findings establish BP as a promising, sustainable excipient with pH dependent release characteristics. The chemical composition and structural differences among Malvaceae polysaccharides underpin their distinct release behaviours with BP's weakly acidic structure favoring pH responsive erosion, grewia's low uronic acid and high degree of branching promoting mechanical reinforcement and okra's balanced composition favouring a stable surface gel formation. This highlights the potential and functional diversity of polysaccharides extracted from the Malvaceae family in the development of environmentally responsible sustained release oral dosage forms.

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[1164] Enhancing the bioaccessibility of lutein and anthocyanins by loading into food-grade biopolymer gels using 3D food printing

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Bioactive food compounds, such as lutein, have numerous health-promoting activities. However, they have poor chemical stability and bioavailability, limiting their efficacy. Thus, in this study, both hydrophobic (lutein) and hydrophilic (anthocyanins) were simultaneously encapsulated into starch/zein gels using an innovative coaxial 3D food printing. Briefly, lutein-loaded zein gel was employed as the core layer, while starch gel was used as the outer layer in a coaxial extrusion 3D printing. A spiral-cube-shaped geometry was used to investigate the effects of layer height (0.4-1 mm), nozzle size (0.33-0.08 mm), printing temperature (55-95 °C), and ink concentrations (10-15%). The effects of different zein concentrations (20, 40, and 60%) and printing speeds (4, 8, 14, and 20 mm/s) were also investigated. The 3D-printed samples were characterized using scanning electron microscopy, Fourier transform infrared spectroscopy, x-ray diffraction, microCT, chemical stability, and simulated digestion methods. The sample printed with a zein concentration of 40% at a printing speed of 14 mm/s exhibited the best shape integrity. When lutein was encapsulated in starch/zein gels, only 39% of lutein degraded after 21 days at 25 °C, whereas 78% degraded at the same time when crude lutein was studied. After storing at 50 °C for 21 days, 20% and 1% of lutein were retained in the lutein-loaded 3D print and control sample, respectively. With the developed 3D printing encapsulation approach, the bioaccessibility of lutein was increased by ~7-fold compared to the crude lutein. Similarly, anthocyanins' chemical stability (42% vs. 70% degradation) and bioaccessibility (38% vs. 20%) were improved compared to the unencapsulated form, respectively. As a result, the developed dual-layered starch/zein encapsulation approach can serve as a platform technology to enhance the stability and bioaccessibility of both hydrophilic and hydrophobic bioactive compounds. The proposed approach allows the food industry to design functional foods loaded with bioactive compounds with higher flexibility and precision.

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[1166] Evaluating Cohesiveness of Hydrocolloid Solutions Using Filament Stretching Extensional Rheometry (FiSER): Insights and Literature Comparison with CaBER

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Cohesiveness is a critical property in hydrocolloid-based formulations for food and health applications, particularly in dysphagia management, where bolus integrity influences swallowing safety and comfort. Traditional assessments using the capillary breakup extensional rheometer (CaBER) have provided insights into fluid cohesion, but its limited control over deformation rate constrains physiological relevance. This work introduces filament stretching extensional rheometry (FiSER) as a complementary approach for characterizing extensional properties of hydrocolloid solutions and blends. FiSER experiments were conducted under constant top plate velocity, enabling controlled filament stretching and generating kinematic data that capture rate-dependent behavior. Measurements on selected hydrocolloid blends are interpreted alongside CaBER findings from the literature, revealing conceptual consistency while demonstrating FiSER's superior reproducibility and sensitivity to formulation differences. By linking extensional response to cohesive strength, these results underscore FiSER's potential for guiding hydrocolloid design strategies aimed at improving bolus cohesion and swallowing safety in dysphagia-oriented applications.

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[1167] Development of Emulsion-based Confectionery product: Understanding the Role of High Sugar Concentration in the Formation, Stability and Rheology of Emulsions

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In the food industry, new product development often aims to expand the range of sensory characteristics. This is especially important in confectionery, where delivery of indulgent flavour and texture is the key. Emulsion technology is widely used in food production for its ability to create unique microstructures. These microstructures contribute to the distinctive texture and mouthfeel of products such as margarine, mayonnaise, and dairy cream. For confectionery, the potential of emulsion technology remains largely untapped. To adopt this technology in confectionery products, several challenges require attention. The complex rheology arising from the high concentration and type of sugar, their impact on the performance of emulsifiers and how they both influence emulsion formation and stability. While previous studies have explored the impact of sugar on emulsifier performance and emulsion formation[1], they have been limited to a narrow range of emulsifiers. Additionally, the sugar concentrations used were not high enough to reflect those typically found in confectionery products.

In this study, the effect of high concentration and type of sugar (sucrose, fructose, and glucose) on emulsion formation, stability and rheological behaviour was evaluated. To assess how sugar influences different emulsifiers' performance, emulsions were prepared with three emulsifiers—Tween 20, whey protein isolate (WPI), and pea protein isolate (PPI)—under varying sugar conditions. Interfacial tension (IFT) and structural changes of emulsifiers were analysed to evaluate their interfacial properties at varrying sugar conditions. To further characterise the resulting emulsions, emulsion droplet size distribution, stability and rheology were assessed. It is shown that while different sugar types had little effect on IFT, different sugar concentrations led to distinct IFT values with the presence of emulsifier at the same concentration. This can be explained by the impact of sugar on emulsifier strucural changes and performance[2]. Higher sugar concentrations resulted in smaller mean droplet size and a more monodisperse distribution. This outcome may be attributed to two factors, the significantly different continuous phase viscosity and the changes of IFT under varrying sugar conditions[3,4].

Despite the difference in droplet size and distribution, the rheological behaviour of emulsions prepared under varying sugar conditions remained consistant. The above factors also further influence emulsion stability. While all the emulsions maintained stable against droplet size changes, higher sugar concentrations demonstrated improved resistance against creaming, except the PPI emulsions at high sugar concentration, which exhibited flocculation and behaved differently from the other samples. In conclusion, sugar concentration and its type impact emulsion formation and stabilty by influencing continuous phase rheology and emulsfier performance. Higher sugar concentrations result in smaller droplet sizes, monodisperse distributions and improved stability.

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Return to program.

[1169] Protein extraction of Pereskia aculeata leaves – effects of ultrasounds and Ohmic heating on their physical-chemical and acid gelling properties

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Leaf proteins are gaining increasing attention as sustainable, nutrient-rich alternatives to animal and legume proteins. Among them, the leaves of *Pereskia aculeata* Miller (PAM) stand out due to their high protein content (14.3–29.0% dry basis) and favorable nutritional profile. This study pursued two objectives: (i) to extract PAM leaf proteins (PAM-LP) from PAM leaf flour (PAM-LF) by alkaline solubilization followed by isoelectric precipitation, and (ii) to investigate how ultrasound (US), Ohmic heating (OH), and conventional thermal treatment (TT) influence the physicochemical and acid-gelling properties of the resulting PAM protein concentrate (PAM-PC). PAM-LF was dispersed in 0.1 M NaOH, centrifuged, and the recovery supernatant was acidified to pH 3.0. This step was followed by multiple centrifugations in which the supernatants were replaced with acidified water (pH 3.0). The final pellet was solubilized in water, adjusted to pH 7.0, and freeze-dried to obtain the PAM-PC. Aqueous suspensions of PAM-PC (2% w/w protein) were then treated by US (20 kHz, 80% of 550 W, 5-s on/off pulses, 10 min), OH

(31 V/cm to reach 90 °C for min, kept by 10 pulses), or TT (90 °C for 5 min in sealed bottles). The resulting samples - Control, US, OH, and TT - were evaluated for zeta potential, isoelectric point, particle-size distribution, protein solubility, viscosity, and thermal behavior. Acid-induced gelation was assessed by adding glucono-δ-lactone (GDL) and analyzing pH kinetics, oscillatory rheology (amplitude and frequency sweeps), confocal microscopy, and water-holding capacity. The extraction procedure yielded 27% protein recovery and increased protein content from 15.3% in the flour to 55.4% in the concentrate. The amino acid profile confirmed that PAM-PC retained the favorable essential amino acid composition of PAM-LF and showed a higher proportion of sulfur-containing essential amino acids. Although PAM-LF is rich in calcium, 97% of this mineral was removed during extraction. SDS-PAGE revealed molecular masses of proteins consistent with RuBisCO (approximately 15 and 55 kDa), and FTIR spectroscopy showed a predominance of β-sheet structures. PAM-LP exhibited a negative charge of ≈ −35 mV at neutral pH and a low isoelectric point (≈ pH 2.0). Particle-size measurements indicated three particle populations in Control and US samples, whereas OH and TT suspensions contained only larger fractions (≈ 5 and 45 μm), reflecting heat-induced aggregation. Nevertheless, protein solubility was remarkably high (>92%) across all treatments. All samples displayed similar denaturation temperatures near 80 °C. Compared with US, both OH and TT increased viscosity, reduced denaturation enthalpy, and enhanced acid-gel elasticity. Indeed, acid-induced gels displayed gel-like (“weak-gel”) behavior, with elastic moduli exceeding viscous moduli and both moduli depending on frequency (Figure 1). Confocal microscopy supported this profile, revealing dispersed protein aggregates instead of a continuous network. Water-holding capacity of the gels was low for all samples, consistent with their weak-gel nature, the low protein concentration used (2% w/w), and final pH of the (~4.1), well above the isoelectric point of PAM-LP (~pH 2.0). Overall,

PAM-LP showed efficient extractability, high solubility, and the ability to form acid gels, reinforcing their potential for incorporation into diverse food applications.

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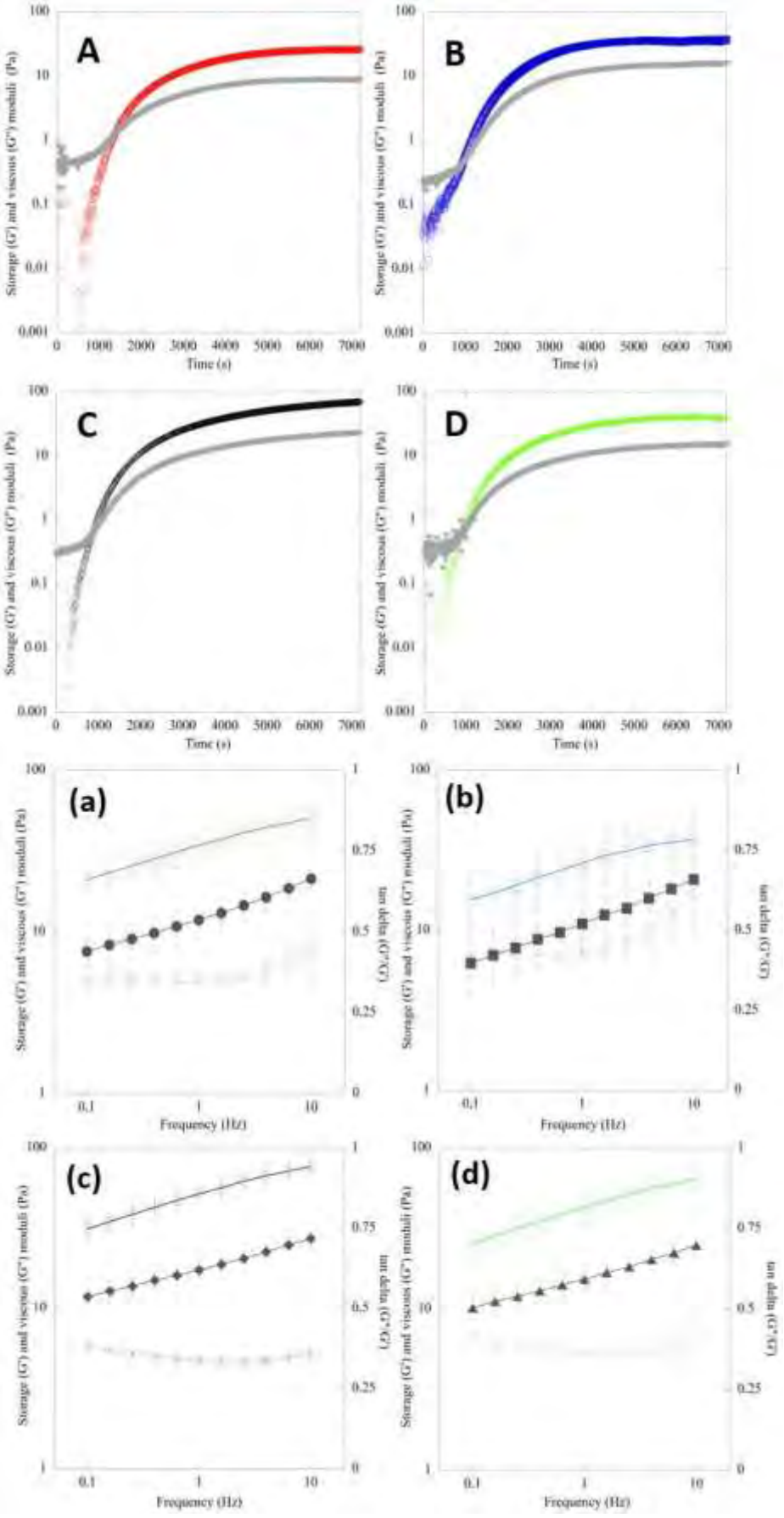
A
B
C
D
(a)
(b)
(c)
(d)
Storage (G') and viscous (G") moduli (Pa)
tan delta (G"/G')
Time (s)
Frequency (Hz)

Figure 1 (A–D) Acid gelation kinetics after GDL addition: storage modulus (G') is shown as red circles (Control), blue squares (US), black diamonds (OH), and green triangles (TT); the corresponding loss modulus (G") is shown as inverted grey triangles. (a–d) Frequency sweep tests: G' (open symbols) and G" (solid black symbols) are represented using the same color code (Control: red circles; US: blue squares; OH: black diamonds; TT: green triangles). The secondary Y-axis displays the loss tangent (tan δ = G"/G') as a function of frequency. Lines are only a guide to the eye.

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1171 Fermentation-assisted extraction and structural characterization of β-glucans from shiitake mushroom by-products

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This study investigates *Lactiplantibacillus plantarum* fermentation as a clean-label pretreatment to enhance the extraction and structural characterization of β-glucans from *Lentinula edodes* (shiitake) by-products. Shiitake residues are rich in β-(1→3)/(1→6)-glucans with established immunomodulatory and anti-cancer potential; however, their recovery is often limited by cell-wall rigidity and poor solubility. The objective was to elucidate how microbial fermentation improves accessibility to β-glucan-rich fractions and induces structural changes in the extracted polysaccharides.

Dried shiitake by-products were fermented with *L. plantarum* under controlled conditions (5% w/w substrate, 0.25% inoculum, 40 °C, 5 h) and compared with unfermented controls. Following fermentation, polysaccharides were extracted by mild alkaline treatment and ethanol precipitation. Structural features were examined using HPAEC–PAD for monosaccharide composition, HPSEC–MALLS–RI for molecular weight distribution, GC–MS for glycosidic linkage analysis, and 1D/2D NMR spectroscopy for detailed structural confirmation.

Fermentation increased polysaccharide extraction yield from 4.9% to 8.8% (w/w) and total monosaccharide content from 68% to 93%. Glucose and galactose were the predominant monosaccharides, indicating that fermentation enhanced cell-wall disruption and solubilization of β-glucan domains. HPSEC–MALLS revealed a broader molecular weight distribution in fermented samples, suggesting improved recovery of structurally diverse polysaccharides. GC–MS and NMR analyses confirmed a β-(1→3)-linked main chain with β-(1→6)-linked side branches; fermented samples showed an increased proportion of →6-linked residues, suggesting selective debranching and enrichment of linear glucan segments through microbial acidification and enzymatic modification.

This work demonstrates a sustainable bioprocess for valorizing mushroom processing residues into high-quality polysaccharide ingredients. Enhanced extraction of β-glucan fractions with defined linkage characteristics provides a foundation for developing health-promoting, clean-label ingredients. The findings contribute to understanding how controlled fermentation can improve accessibility to complex fungal polysaccharides and support their application as functional hydrocolloids and bio-based components in the food industry.

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[1175] Short-soluble amylose chains inhibit long-term retrogradation and modulate *in vitro* digestion of waxy corn starch gels

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Objective: Short-soluble amylose has been documented to inhibit gelatinisation and short-term retrogradation of waxy corn starch via deposition of amylose coat over the granules. This study further investigates the effects of short-soluble amylose chain envelopes on the long-term retrogradation and *in vitro* digestibility of waxy corn starch gels.

Methodology: Commercial waxy corn starch (Amioca TF) and isolamylase were supplied by Ingredion Incorporated, USA and Megazyme, Ireland respectively. Short-soluble amylose (DP ≤ 1000) was fabricated from waxy corn starch by isoamylase hydrolysis (40 °C, pH 4.0, 24 h) coupled with aqueous fractionation at 25 °C. Waxy corn starch: short-soluble amylose chain was combined in ratios, 1:0.25, 1:50, 1:0.75 and 1:1 (parts by weight) and named AP25W1-5 respectively. Samples prepared by DSC were used to assess retrogradation enthalpy and retrogradation kinetics by using the Avrami Equation. Samples prepared by RVA at week 0, followed by storage at 4 °C were

withdrawn from storage at the end of week1, 4 and 6, snap frozen at -80 °C and lyophilised for *in vitro* digestion and release kinetics.

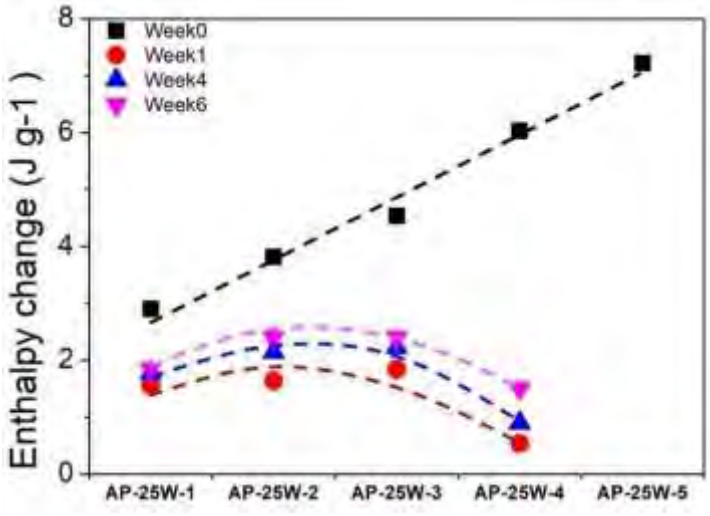

Fig. 1. Effects of short-soluble amylose chains on the thermal properties of retrograded waxy corn starch gels during storage at week0 (■), week1 (●), week4 (▲) and week6 (▼). Here, enthalpy is represented as a function of degree of addition of 25W. AP-25W-1, AP-25W-2, AP-25W-3, AP-25W-4 and AP-25W-5 represents waxy corn starch: short-soluble amylose chain ratios, 1:0, 1:0.25, 1:0.50, 1:0.75 and 1:1 respectively. For total mass balance, 75%, 68.75%, 62.5%, 56.25%, and 50% (w/w) water was added, respectively. Black dashed line is a visual guide to indicate linear behaviour. Red, blue and magenta dashed line are a visual guide to indicate second-order polynomial behaviour. AP: amylopectin from waxy corn starch; 25W: soluble amylose chains extracted from waxy corn starch at 25 °C; W: waxy corn starch source.

Results and Conclusion: Short-soluble amylose is previously known to inhibit gelatinisation and short-term retrogradation of waxy corn starch amylopectin, and our study reveals further key findings from long-term storage retrogradation. When blended with waxy corn starch at different ratios (w/w), these short-soluble amylose chains can (a) completely inhibit long-term retrogradation of amylopectin at higher addition ratios (> 1:0.50, w/w) and (b) modulate susceptibility to enzymatic digestion, co-relatable to the formation of slowly digestible and resistant types of starches, as blending ratios (w/w) and storage times (weeks) increase.

Our investigation reveals for the first time, a concentration-dependent inhibitory and modulatory effect of short-soluble amylose chains on gelatinised and retrograded waxy corn starch amylopectin. These findings will allow food processors and manufacturers to fine-tune starch structure-function (structure-digestion) to meet various food processing and non-food application requirements. This study also promises a cleaner additive label since amylose is a natural component of starch and exhibits interesting potential for designing slow digestible and resistant starches for glycemic index control in diabetes management and therapy.

Keywords. Soluble amylose, Waxy corn starch, Retrogradation, Structure, Digestion

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[1177] Construction of a pH-driven self-assembled soy protein–lecithin microcage embedded in a κ-carrageenan hydrogel for weight-management

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Obesity significantly reduces quality of life and imposes a substantial socioeconomic burden. Increasing evidence links excessive fat intake to elevated risks of cardiovascular disease, certain cancers, and multiple chronic diseases. Therefore, the development of an effective dietary supplement that can mitigate intestinal fat absorption is of considerable interest. This study provides systematic evidence for a pH-engineered lecithin–soy protein microcage embedded within a κ-carrageenan hydrogel matrix for targeted intestinal fat trapping.

To fabricate the microcage, lecithin (2%) and soy protein isolate (2%) were dispersed in ethanol and mixed at 60 °C for 4 h under 500 rpm stirring. A pH-shifting treatment (pH 3, 7, and 10) was then applied to modulate the soy protein–lecithin phospholipid interactions and promote a functional self-assembly. The resulting dispersion was evaporated to dryness to remove ethanol and reconstituted in Milli-Q water. This concentrated suspension was introduced dropwise into a 2% κ-carrageenan solution (60 °C, 500 rpm, 4 h) to form a composite hydrogel, followed by cooling and overnight crosslinking in 0.3% KCl.

Comprehensive characterisation was conducted to evaluate the microcage formation, embedding efficiency, and digestive behaviour. FTIR, SEM, intermolecular force analysis, dynamic oscillation, and contact-angle measurements collectively demonstrated that the lecithin–soy protein microcages were stabilised predominantly by

hydrophobic interactions. Particle-size analysis and CLSM confirmed successful incorporation of ~1 μm microcages into the κ-carrageenan network. pH shifting significantly influenced both zeta potential and hydrophobicity: microcages were positively charged at pH 3, while negative zeta potentials were observed at pH 7 and 10. Hydrophobicity increased markedly at pH 10, attributed to the enhanced exposure of hydrophobic domains caused by protein unfolding under alkaline conditions. Interactions with κ-carrageenan were likewise pH-dependent—positively charged microcages at pH 3 bound electrostatically to the anionic polysaccharide, whereas neutral or negatively charged microcages at higher pH were primarily incorporated through physical entrapment within the gel network.

In vitro oil-absorption capacity, evaluated using GC-FID and CLSM, revealed that the κ-carrageenan–embedded microcages absorbed at least 50% of added rice bran oil, with strong retention of long-chain fatty acids (e.g. palmitic acid; C16 and linoleic acid; C18:2), likely due to their pronounced hydrophobic nature. Among all treatments, the pH 10 microcage system exhibited the highest absorption capacity, consistent with its increased hydrophobicity. *In vitro* digestion studies also demonstrated that the composite hydrogel maintained structural integrity throughout gastrointestinal transit without being fragmented into fine particles, indicating its potential for safe passage and excretion following lipid sequestration.

Overall, this work presents a practical and scalable strategy for constructing protein–phospholipid microcages embedded within a carrageenan matrix for targeted intestinal oil entrapment. The findings provide new insights into pH-induced hydrophobic modulation in microcage assembly and subsequent function, offering a useful approach for developing the next-generation of fat-reducing dietary supplements.

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[1178] Functional properties of cold-set agar-based emulsion gel for fat replacer in fish sausages

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Fat reduction in meat products often compromises texture, water retention, and sensory quality. Emulsion gels have been proposed as effective fat replacers, but their properties depend on the preparation method. This study aimed to evaluate the functional properties of *Gracilaria fisheri* agar-based emulsion gels prepared using cold-set and hot-set methods, and to determine their suitability as fat replacers in fish sausages. The two emulsion gels were first compared for gel strength, water-holding capacity (WHC), and viscoelastic behavior. The hot-set emulsion gel (HEG) showed slightly higher gel strength (994.95 ± 62.20 g) than the cold-set emulsion gel (CEG) (942.42 ± 57.54 g), with no significant difference. In contrast, CEG exhibited significantly ($p < 0.05$) higher water-holding capacity (83.61 ± 0.43%) compared with HEG (68.78 ± 2.52%). Both gels showed similar viscoelastic behavior and crossover temperature (~80 °C). Given its superior water retention, CEG was incorporated into fish sausages at different fat replacement levels (0–100%). During storage (7 days, 4 °C), lightness (L*), yellowness (b*), pH, and oxidative stability of raw sausages changed significantly ($p < 0.05$), although thiobarbituric acid (TBA) values (0.04–0.87 mg MDA/kg) did not differ from the control. For cooked sausages, 50% fat replacement with CEG produced samples with comparable physicochemical and textural properties (adhesiveness, springiness, resilience, cooking loss <10%) to the control. Importantly, oxidative stability improved significantly (TBA: 0.03 mg MDA/kg). Overall, *G. fisheri* agar-based cold-set emulsion gels, particularly at 50% fat replacement, represent an effective fat substitute that maintains product quality while enhancing oxidative stability. These findings highlight the potential of seaweed-derived hydrocolloids for developing healthier meat products aligned with dietary recommendations for reducing fat intake.

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[1180] *Chlorella* Polysaccharides as Compositional Modulators of Network Organization in Edible Fiber Scaffolds

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The demand for cultivated meat has highlighted the need for edible scaffolds capable of providing both structural stability and hydration-mediated material performance. *Chlorella* contains polysaccharides that can modulate water retention and mechanical reinforcement by forming hydrogen-bonding networks and promoting polymer chain entanglement within composite matrices. However, a large fraction of these polysaccharides remains sequestered behind the rigid microalgal cell wall, limiting their functional contribution to scaffold systems.

To improve the availability of intracellular polysaccharides, microwave-assisted extraction was employed, utilizing dielectric heating and ionic conduction to disrupt the *Chlorella* cell wall and obtain polysaccharide-rich extracts from chromatic *Chlorella* types (yellow, white, and green) that are relevant to hydration behavior and network organization within edible scaffold systems. Polysaccharide levels were quantified by the phenol-sulfuric acid method and used as a compositional index for scaffold formulation. Gelatin-chitosan fiber scaffolds incorporating these extracts were fabricated and characterized through rheological, structural, and physicochemical analyses.

Differences in extract polysaccharide content have the potential to modulate hydration capacity, fiber-forming behavior, and scaffold stiffness, positioning *Chlorella*-derived

polysaccharides as a compositional variable linked to network organization within edible fiber matrices. Identifying how these extract-driven changes correlate with scaffold structure and cellular interactions will clarify the role of *Chlorella* polysaccharides in cultivated meat scaffold design and establish a basis for material optimization using food-grade microalgal components.

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[1181] Development of a Double-Network $CaCO_3$-GDL Crosslinked Bioink for Cell-Compatible and Edible Scaffolds in Cultivated Fish

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Three-dimensional (3D) printing offers a promising approach for fabricating customized scaffolds in cultivated meat. However, challenges remain achieving sufficient mechanical stability using food-grade materials, ensuring micron-level precision, and maintaining low-temperature compatibility suitable for fish cells.

To address these limitations, a bioink was designed using a double-network crosslinking strategy. The first network was formed through hydrogen bonding and polymer entanglement among iota-carrageenan (IC) for low-temperature gelation, sodium alginate (SA) for viscosity control, and cellulose nanocrystals (CNC) for enhanced strength and printing stability. An additional ionic network was introduced using $CaCO_3$ and glucono-δ-lactone (GDL), completing the double-network structure. In

polysaccharide-based bioinks, this internal gelation approach is widely employed to achieve gradual and uniform crosslinking, overcoming the rapid and uneven gelation associated with caused by $CaCl_2$. However, $CaCO_3$–GDL system induces a gradual pH drop during crosslinking, which may compromise the viability of fish cells. Moreover, although $CaCO_3$ – GDL internal gelation is widely used in biomedical applications, it has not been systematically examined in the context of cultured meat. Therefore, this study aims to define the optimal range of gelation rate, printability and cell viability, establishing fundamental criteria for developing edible and cell-compatible scaffolds for cultivated fish.

Different combination of SA, IC and CNC were formulated and screened to identify the minimum gelation concentration. Rheological tests were conducted to confirm whether the inks exhibited suitable viscoelasticity for extrusion printing. The printability was further evaluated by measuring the minimum extrusion pressure and assessing printing fidelity. To determine optimal crosslinking conditions, pH changes at different GDL concentrations were monitored, as a drop below pH 6 may affect fish cell viability. Time sweep tests were then performed to verify gelation behavior over time. Based on the selected GDL concentration, degradation tests were carried out to assess long-term structural stability. Finally, the cytocompatibility of the bioinks was examined using leachate solutions for cell viability assay.

Increasing SA content enhanced the storage modulus (G'), whereas higher IC ratios accelerated gelation. Rheological analyses exhibited pronounced shear-thinning behavior, indicating adequate viscoelasticity for extrusion printing. The printed constructs demonstrated moderate shape fidelity with the rheological findings. pH monitoring revealed a gradual decrease from 7.4 to 6.2 with increasing GDL concentration, suggesting a controllable internal gelation window applicable for cell compatibility. Time sweep measurements showed a faster rise in G' at higher GDL levels, confirming accelerated crosslinking kinetics. The printed products maintained their structural integrity up to 14 days, and cell viability tests using the leachate indicated approximately 80% survival, validating the cytocompatibility of the developed bioink.

These findings demonstrate that $CaCO_3$ – GDL based double-network bioink enables controlled gelation, stable printability, and favorable cytocompatibility, providing a practical foundation for developing edible and cell-compatible scaffolds in cultivated fish.

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[1182] Development of 3D-Printable Marine-Derived Gels for Senior-Friendly Seafood Analogues

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The global aging population has heightened the need for nutritional solutions tailored to elderly individuals. In South Korea, seafood consumption among adults aged 65 and above has increased over the past decade, accounting for approximately 12% of total animal protein intake. Despite a growing preference for meat, seafood remains an important protein source for the elderly population. However, many older adults with reduced chewing and swallowing abilities experience difficulty consuming conventional fish products. To address this challenge, this study aimed to develop a senior-friendly alternative seafood that meets both the nutritional requirements and textural accessibility of elderly consumers. To achieve this, 3D-printable fish analogues mimicking the texture and rheological behavior of real fish were developed using marine-derived ingredients as sustainable structuring materials. Composite gels were formulated with *White Auxenochlorella protothecoides*, methylcellulose, flaxseed oil, and seaweed-derived polysaccharides (agar, iota-carrageenan, and kappa-carrageenan). Textural, rheological, molecular, and microstructural analyses were conducted to evaluate the physicochemical characteristics of the developed gels compared to those of real fish. Among the three gelling agents, agar-based gels exhibited the most similar viscoelastic response and structural uniformity, confirming their superior suitability as marine-based structuring materials. Further analysis revealed that agar concentration

played a key role in modulating the mechanical properties of the gels, particularly hardness. This tunability demonstrates the potential of agar-based gels for designing senior-friendly foods, in which hardness is a key determinant defined by the KS H 4897 standard. Based on these findings, printable inks were formulated to achieve hardness levels corresponding to the tongue-, gum-, and teeth-intake categories. Moreover, all samples exhibited pronounced shear-thinning behavior and high structural recovery, confirming their suitability for extrusion-based 3D food printing systems. This study presents a framework for developing senior-friendly alternative seafood through the control of marine-derived hydrocolloids, demonstrating agar's tunability as a structuring material and offering practical insights for 3D food printing aimed at personalized food applications in the elderly.

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[1183] Tensile-Spun Gelatin-Chitosan Composite Scaffolds for Exploring Architecture-Cell Interaction Relationships

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Engineering fibrous scaffolds with controllable structural and mechanical attributes is critical for reproducing the anisotropic organization and functional microenvironment of skeletal muscle. In this study, we developed gelatin-chitosan (GC) scaffolds using a toxic solvent-free tensile spinning process that, resulting in aligned fiber assemblies. Adjusting the chitosan fraction systematically altered the viscoelastic properties of the precursor mixture, which directly influenced fiber formation, pore characteristics (20-

26%), hydration resilience, and stiffness (3-87 kPa). Spectroscopic and diffraction analyses revealed strengthened molecular interactions and increased structural order with chitosan incorporation. In parallel, surface charge measurements confirmed compositional regulation of electrostatic cues governing cell-matrix interactions.

Among the tested formulations, mid-range compositions ($GC_{1.00}$-$GC_{1.75}$) achieved an advantageous combination of limited swelling, persistent mass transport, and stable mechanical behavior under hydrated conditions. In particular, $GC_{1.25}$ scaffolds promoted robust myoblast attachment, high viability, and pronounced alignment of the actin cytoskeleton, driving directional myotube development along the fiber axis. Collectively, these results highlight gelatin-chitosan composites as a versatile system for dissecting how polysaccharide-protein interactions and rheological tuning dictate scaffold architecture, charge environment, and downstream myogenic outcomes. The approach outlined here offers a practical foundation for creating architecturally defined fibrous scaffolds capable of sustaining cellular organization and function.

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[1186] Protein Composition and Purity Modulates Structural Transitions of Sunflower and Lupin Proteins During Hydrothermal Processing

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The transition from animal-based proteins to plant-based alternatives is essential to address environmental concerns and promote sustainable food systems. Plant-proteins are mainly available as either concentrates (~50-80% protein) or isolates (>80% protein), which vary not only in purity and composition but also in their protein structural organization and functionality, concurrently associated with their extraction method and source. To unravel these effects, the heat-processing behavior of two protein sources were studied: sunflower, a by-product of oilseed extraction, and lupin, a protein-rich legume with high fiber content. These proteins were evaluated as concentrates (50–53% protein), along with their corresponding laboratory-prepared isolates, obtained by alkaline extraction-isoelectric precipitation (80–85% protein), which were systematically compared to commercially available lupin and sunflower protein isolates (90–92%). The proteins were characterized for their nativity, molecular weight, globulin/albumin fractions, surface hydrophobicity, solubility, and gelation to establish structure–function relationships. To evaluate their gelation behavior, the 6 proteins were subjected to hydrothermal processing under high-moisture (20% solids), low-shear conditions at either 95 °C or 140 °C, representing moderate and severe heat-treatments. The processed samples were analyzed for microstructure and protein solubility. The studied proteins differed in subunit composition: sunflower proteins and the commercial lupin isolate were mainly composed of 11S legumine-like globulins, whereas lupin concentrate and its laboratory isolate contained both 7S and 11S globulins, with a 7S predominance. Notably, only the commercial sunflower isolate was pre-denatured, while the others were native, enabling assessment of the effect of protein nativity on functional behavior. Regarding surface hydrophobicity, the extraction method had a clear impact, with both commercial isolates being the most hydrophobic, especially the pre-denatured sunflower isolate. Sunflower and lupin concentrates exhibited intermediate levels, while the laboratory isolates showed the lowest hydrophobicity due to their carefully controlled isolation conditions. After hydrothermal processing at 95 °C, sunflower concentrate showed the highest gel viscosity, followed by its laboratory isolate, while the commercial isolate exhibited an almost flat profile near zero throughout the measurement. Meanwhile, lupin concentrate and its laboratory isolate exhibited similar heat-viscosity profiles with much lower gel viscosity than sunflower proteins. Conversely, the commercial lupin isolate showed only a brief initial increase due to cold-water absorption, followed by very low viscosity. During hydrothermal processing at 140 °C, sunflower concentrate displayed higher viscosity but also greater breakdown and lower final viscosity than at 95 °C. Both sunflower isolates, particularly the commercial one, exhibited a spiky viscosity profile during cooling, indicating protein aggregation. In contrast, lupin concentrate displayed a second peak not observed at 95 °C or in its laboratory isolate at 140 °C, suggesting contributions from non-protein components or dissembling and solubilization of larger protein aggregates. The commercial lupin isolate showed higher final viscosity compared to its near-zero

viscosity at 95 °C, although it did not reach gel formation (below least gelation concentration). Microscopy revealed larger aggregates in sunflower samples with increasing heat-treatment, likely due to the predominance of 11S globulins, whose hydrophobic nature and disulfide bonds could promote further re-aggregation. Meanwhile, lupin samples remained more homogeneous across treatments, with only slightly coarser particles at 140 °C, mainly in the isolates. Protein solubility (indicative of the protein fraction not contributing to the network) generally decreased under severe heat conditions, except for the sunflower laboratory isolate, which remained stable, and both commercial isolates, which increased at 140 °C, suggesting a higher protein de-aggregation during high temperature conditions. Overall, these findings demonstrate how protein origin, purity, and structure influence structural changes and gelation during heat processing, underscoring the importance of thorough ingredients characterization, and providing a deeper understanding for the design of plant-based food systems with enhanced functionality.

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[1189] Effect of pectin on calcium release from acid-induced pea protein gels during dynamic *in vitro* digestion

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Plant-based dairy alternatives often require calcium fortification and texture modifiers or stabilisers to meet both the nutritional and functional standards of their dairy counterparts. Dietary calcium intake is determined not only by the amount consumed but also by the efficiency of its delivery, which depends on its release from the food matrix during digestion. Structural changes arising from texture modifiers, as

well as interactions between calcium and these modifiers, may influence calcium release and bioaccessibility during digestion; however, research on this topic remains limited.

In this study, a plant-based yoghurt alternative model was developed using 5% pea protein and 1% GDL to induce acid gelation. The acid-induced gels were fortified with insoluble $CaCO_3$ (30 mM; 1200 ppm Ca) and modified using different doses (0, 0.2, and 1.0% w/w) of a gelling agent, low-methoxyl (LM) pectin. Gel textural and structural properties were characterised using a texture analyser and confocal laser scanning microscopy. The calcium-fortified gels were subjected to dynamic in vitro gastric digestion using a Human Gastric Simulator, combined with static oral and intestinal phases. Digesta were collected at 30-minute intervals to determine pH, total solids, and calcium profiles. Total, soluble, and ionic calcium were quantified using microwave plasma atomic emission spectrometry (MP-AES) and a calcium-selective electrode.

Results showed that gels with higher hardness and more compact microstructure slowed gastric emptying, which in turn delayed total calcium release in both gastric and intestinal phases. However, ionic and soluble calcium release appeared to be unaffected by gel structure or its breakdown during digestion in this acidic gel system. In addition to enhancing gelation, LM pectin stabilised ionic/soluble calcium in the intestinal phase and prevented precipitation with phosphate or carbonate, resulting in a more sustained and higher ionic calcium release in the 1.0% pectin sample.

Overall, these findings indicate that while gel texture does not govern calcium release in acid-induced gels, the incorporation of LM pectin can alter the fate of calcium during digestion. This work provides insights for designing plant-based dairy alternatives that achieve efficient micronutrient fortification alongside desirable techno-functional properties.

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[1191] Bioaccessibility of white mugwort (*Artemisia lactiflora*) polyphenol extract in the system with brown rice flour and inulin revealing by static in-vitro digestion model

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The interactions between food macromolecules, particularly carbohydrates and fiber, with polyphenols are of significant relevance in elucidating the bioaccessibility of bioactive compounds in plants. White mugwort (*Artemisia lactiflora* Wall., BK No.070334), a medicinal plant unique to Thailand, is a promising antioxidant for food fortification due to its phenolic acids (5-CQA, 3-CQA, 3,5-diCQA) and flavonoids (quercetin, kaemferol, morin, rutin, isovitexin). This study employed the Infogest static model for in-vitro digestion to examine the bio-accessibility of these compounds with carbohydrates (brown rice flour) and fiber (inulin). When the white mugwort extract powder (WME) was digested with these food macronutrients, structural modifications and hydrolysis occurred, resulting in reduced polyphenol bio-accessibility, particularly during the intestinal phase due to alkaline conditions. Moreover, WME was found to be delayed the brown rice starch digestion due to the ability to inhibit pancreatic amylase activity through non-covalent interaction. This reaction is formed between hydroxyl groups of phenolic and polar groups of enzymes. Moreover, inulin was detected to show the negative impact on bio-accessible polyphenols more than brown rice flour which could be due to the higher dietary fiber content of inulin over brown rice flour and the stronger binding capacity of polyphenols-dietary fiber. These reversible non-covalent interactions can be further metabolized by gut microorganisms before polyphenols are metabolized and reabsorbed in the large intestine. These findings suggest that consuming plant extract with other food macromolecules is not preferable to adding high concentrations of fiber powder. Naturally occurring plant fiber at lower levels does not significantly affect polyphenol bio-accessibility.

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[1192] Fish Gelatin/Chitosan Microfiber-Based 3D Porous Scaffolds Constructed with Pickering Emulsion and 3D Printing for Cell-Cultivated Meat

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Global seafood demand continues to increase, raising concerns over resource depletion and environmental impact. As a sustainable alternative, cell-cultivated fish requires edible scaffolds that support cell adhesion and tissue formation. This study developed a hierarchical 3D porous scaffold using fish gelatin/chitosan microfibers (FG/C-MF) via Pickering emulsion templating and 3D printing to enhance structural and biological performance.

Fibrous scaffolds were ground into fine FG/C-MF particles and used to prepare Pickering emulsion ink. Particle morphology was examined by SEM, and their wettability and emulsifying ability were evaluated through contact angle measurements. The pH-dependent aggregation behavior was analyzed using zeta potential and optical microscopy. Since FG/C-MF tended to collapse after freeze-drying due to weak interparticle bonding, transglutaminase (TGase) crosslinking was applied to enhance structural integrity. The emulsion stability index (EI) before and after TGase treatment and the internal morphology under varying oil fractions were analyzed by SEM. Rheological measurements were conducted to evaluate printability, and both molded and 3D-printed scaffolds were compared in terms of compressive strength and cell adhesion. Cell viability and distribution were visualized using Live/Dead staining.

The fibrous scaffolds were successfully converted into microfibrous particles, and stable suspensions were obtained by pH adjustment, which suppressed particle aggregation. TGase crosslinking markedly improved structural stability after freeze-drying. The internal pore size and interconnectivity varied depending on the oil fraction, leading to differences in porosity, mechanical integrity, and cell affinity. Rheological analysis confirmed that FG/C-MF-based Pickering emulsion ink exhibited viscoelasticity suitable for 3D printing. The printed scaffolds showed greater compressive strength and cell adhesion than molded ones, and Live/Dead staining demonstrated uniform cell attachment and high viability.

This study introduces a Pickering emulsion–based 3D printing strategy that enables tunable pore architecture and enhanced stability, advancing hierarchical porous scaffold technology for cultured seafood production.

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[1194] Ultrafast gelation of hyaluronan hydrogels via alternate compression-decompression

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High pressure-induced inter/intra-hydrogen bonds are strong enough to sustain micro-assemblies. Here, for the first time, we demonstrate a rapid route (several minutes) for dynamic pressure to enable effective gel formation from hyaluronic acid (HA). The HA hydrogels prepared in such an alternate compression-decompression procedure exhibit a layered structure and high yield of as-made gels. Compared to conventional freeze-thawed hydrogels, the gels via alternate compression-decompression (ACD) have an enhanced intermolecular interaction as well as improved mechanical properties. This method is fast, simple, and safe. Furthermore, the present results provide new ideas for obtaining physical gels and contribute to the development of HA-based materials that can be used in biomedical and agricultural applications.

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[1197] Cellulose-based foam-mat freeze-dried clove essential oil nanoemulsion as a natural food preservative

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Cellulose-based foam-mat freeze-dried clove essential oil nanoemulsion (FFD-CN) was fabricated and investigated for its efficiency to preserve food quality. The clove essential oil nanoemulsion (CN) was prepared from 1% (v/v) clove essential oil and 3% (v/v) Tween® 80 using ultrasonication. The optimal condition for fabrication of FFD-CN, optimized using response surface methodology, was found at 3% (v/v) of methyl cellulose (Methocel™) as a foaming agent, 60 °C drying temperature, and 72 h drying time. The obtained FFD-CN had the droplet size of 26.14 nm, polydispersity index (PDI) of 0.193, water activity (a_w) of 0.273, solubility of 88.71%, and viscosity of 12.85 cP. The FFD-CN exhibited good stability and antimicrobial activity during 3 month storage at 25°C. The FFD-CN and CN were then applied as a natural preservative to preserve quality of shrimp. The shrimp samples were monitored for trimethylamine, total volatile basic nitrogen, total viable count, and color during chilled storage at 4 ± 2°C. The results showed FFD-CN outperformed CN for preserving the quality of whiteleg shrimp. Gas chromatography-mass spectrometry results revealed that FFD-CN can stabilize eugenol, a major volatile bioactive compound in clove oil, better than liquid-formed nanoemulsion. This suggested that methyl cellulose, due to its surface-active properties and ability to stabilize the resulting foam structures, can effectively provide a protective layer around the essential oil nanoemulsion, which improves long-term stability. FFD-CN can effectively be used as a natural preservative for maintaining the quality of shrimp.

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[1198] Multimodal Fusion of Image, Textural and Colorimetric Features for Prediction of Bread Shelf-Life and Texture Decay

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Bread staling is a temporally dynamic process driven by starch retrogradation, moisture redistribution and structural disintegration of the crumb matrix. While these changes originate within the hydrated starch-gluten structure formed during baking, they are mostly observed as deterioration in texture and appearance during storage. Conventional staling assessment methods like rheological, thermal, moisture and sensory tests are often destructive, time-consuming and limited in capturing the multidimensional, time-dependent kinetics of bread crumb texture deterioration. This study introduces a multitarget machine learning (ML) framework integrating Texture Profile Analysis (TPA), image-based crumb structure analysis and Hunter LAB colour parameters (L*, a*, b*) for prediction of bread shelf-life and texture decay. A dataset of 350 bread crumb samples from five commercial brands stored over seven days at ambient temperature was analyzed. TPA parameters (14) including hardness, cohesiveness, gumminess, chewiness, resilience and springiness were measured using the Texture Analyzer, and day-wise bread slice images were captured for crumb structure. Crumb structure and appearance were characterized through image analysis, while colour parameters to capture time-dependent visual deterioration associated with staling. A Multi-Output Random Forest Regressor was trained to model the nonlinear progression of textural attributes, yielding R^2 values of 0.99 (hardness), 0.96 (chewiness), and 0.94 (gumminess). Extrapolative modelling for days 8 to 10 further confirmed the model's generalizability. An improved Grey Wolf Optimization algorithm was applied for image feature selection, using an Ensemble Random Forest model to identify the top 10 features. The resulting multimodal system, comprising 14 TPA variables, optimized image features, and Hunter LAB parameters, achieved over 98% accuracy in predicting storage period and revealed strong correlations between the crumb structure, colour degradation and textural features. The proposed method enables non-destructive, scalable and reliable estimation of bread staling and shelf-life estimation for intelligent food quality monitoring and lays the groundwork for quality assessment tools based on AI and ML in commercial bakery operations.

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[1199] Enhancing structure formation in pea protein systems through sequential thermomechanical processing for sustainable meat alternatives

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Pea protein concentrates (PPCs) contain not only storage proteins but also naturally occurring hydrocolloids such as soluble fibers, pectic polysaccharides, and cell wall fragments, which influence hydration, viscosity, and network formation during high-moisture extrusion. These endogenous hydrocolloids are increasingly recognized as functional co-structuring agents that can enhance or limit the development of fibrous, anisotropic textures in plant-based meat analogues. However, their interactions with proteins are highly sensitive to thermomechanical history and remain poorly characterized under industrially relevant conditions.

This study investigates a sequential thermomechanical processing strategy designed to modulate protein–polysaccharide interactions in commercial PPC and improve its structuring behavior during high-moisture extrusion. In a first step, PPC was subjected to controlled pre-treatment at low moisture (dry-heat conditioning) to adjust solubility, hydration kinetics, and viscoelastic behavior of the native protein–hydrocolloid matrix. This pre-activation step aimed to partially unfold proteins, redistribute water-binding sites, and enhance compatibility with endogenous soluble polysaccharides, thereby improving the functional readiness of the material for subsequent texturization.

In the second step, pre-treated materials were processed under defined high-moisture extrusion conditions. Structural development was evaluated through mechanical anisotropy, macro-texture analysis, and microstructural imaging.

The results demonstrate that sequential processing significantly enhances the structural performance of pea protein systems. Pre-treated samples exhibited higher water-binding capacity and increased viscoelasticity prior to extrusion. During high-moisture texturization, these functional improvements translated into clearer phase alignment, more pronounced fibrillar structures, and increased anisotropy.

Overall, the findings show that tailoring the thermomechanical history of plant protein ingredients can unlock the structuring potential of their intrinsic hydrocolloid components, enabling high-quality meat analogues without the need for purified gums or additives. This approach offers a sustainable, low-energy route for improving texture in plant-based foods while maintaining clean-label formulations and supporting regional protein production.

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[1200] Bigdata-driven approach for food texture analysis ~ compression and mastication measurements

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Food texture is a key determinant of palatability. While human sensory testing remains crucial for replicating the final consumer experience, obtaining reliable results remains challenging even with established methods like TI, TDS, and TCATA. A significant challenge lies in the discrepancy between TPA characteristic values and sensory test results, probably due to variations in experimental conditions such as tooth morphology, temperature, saliva composition, flavor crosstalk, and masticatory patterns (e.g., chopping and gliding).

Deep learning has gained considerable attention due to its potential to categorize data even with subtle differences. Even for above mentioned type of complex task of food texture, deep learning may be applicable. Huge size of dataset is crucial in general for deep learning, depending on model complexity. Traditional food science research has been limited by the small datasets available (typically on the order of 10~100 measurements). This limitation has restricted the application of deep learning to relatively simple analyses to prevent overfitting.

We have developed automated systems for collecting food compression data and have collected a dataset exceeding 10^5 measurements using conventional 1-axial

and 6-axisal force/torque sensors with teeth shaped plunger. This dataset allows for the detection and analysis of subtle differences, even in foods exhibiting significant textural variations where TPA cannot be applied. The large dataset demonstrates that MLP has the potential to analyze food texture using a fundamentally different approach compared with TPA.

Despite the extensive dataset of compression measurements, a critical gap still remains in replicating the variability of experimental conditions encountered during instrumental compression measurements. To address this gap, 3D scanning of facial movements during chewing using a smartphone-integrated 3D sensor was employed to collect a large-scale dataset of human mastication behavior. Chewing behavior is significantly influenced by both food texture and flavor profiles. A dataset exceeding 10^5 of mastication behavior has already been collected. More detailed analysis tightly related to sensory evaluation was possible with mastication behavior compared with compression measurements.

Deep learning-based food texture analysis integrating compression and chewing measurements provides a promising way for detecting subtle textural differences and bridging the gap between human sensory scores and instrumental evaluations.

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[1202] High Internal Phase Emulsion of Sardine Oil Stabilized by Sodium Caseinate–Carrageenan Complexes: A Colloidal Approach to Omega-3 Enrichment in Freshwater Fish Surimi

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High Internal Phase Emulsions (HIPEs) offer a novel strategy for structuring liquid oils into semi-solid systems with improved stability and functionality. This study aimed to synthesize HIPE-based emulsion gels from sardine oil by-products and evaluate their potential as colloidal lipid carriers to enrich omega-3 fatty acids and enhance texture in freshwater fish surimi, which inherently has low lipid content and weak gel strength. HIPE gels were formulated using sodium caseinate (SC) and carrageenan (CAR) as emulsifiers at oil phase fractions of 30%, 50%, and 70%. The 70% HIPE formulation exhibited superior stability, showing minimal oiling-off (1.76%) and the smallest mean droplet size (32.82 μm). Confocal laser scanning microscopy (CLSM) revealed a continuous and homogeneous microstructure. Rheological analysis demonstrated solid-like viscoelastic properties (G′ > G″), confirming the formation of a strong internal network. When incorporated into surimi at 15% (w/w), the HIPE gel significantly improved texture, with hardness of 2469.16 ± 0.94 N, springiness of 83.88 ± 0.27%, cohesiveness of 0.60, and protein content of 16.18%. These results suggest that marine oil-based HIPE gels can function as stable omega-3 delivery and texturizing systems, enhancing both nutritional value and structural integrity in freshwater fish products. The integration of food-grade hydrocolloids within HIPE systems provides a sustainable and functional lipid structuring strategy for next-generation protein-based foods.

Keyword: hydrogel, Hydrocolloid stabilization, oleogel, Omega-3 delivery system

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[1203] Ultrasound-assisted extraction and colloidal properties of protein isolates from neglected Sicilian black chickpeas

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The valorization of underutilized legume varieties supports biodiversity and enhances food system sustainability, while offering plant-based protein ingredients with distinctive structural and colloidal functionality suitable for tailored food applications. This study investigated the effects of ultrasound-assisted extraction on the physico-chemical and functional properties of protein isolates from two neglected black chickpea (*Cicer arietinum L.*) cultivars originating from Sicily, southern Italy. These varieties, which were abandoned over time due to their dark color and lengthy preparation time, are today reconsidered for their tolerance to drought and high temperatures, underscoring their importance in the context of climate change.

To valorize these legumes as sustainable protein sources, conventional alkaline extraction (ST-treated) was compared with ultrasound-assisted extraction (US-treated), both performed at pH 9 and a 1:10 (w/v) solid-to-liquid ratio. Ultrasound was applied at 20 kHz and 80% amplitude for 5, 10, or 15 minutes, and the colloidal behavior of the resulting isolates was further examined through the preparation of model oil-in-water emulsions using high-pressure homogenization.

Ultrasound improved protein extraction performance, acting as an effective green processing strategy. The US treatments increased protein extraction yield (20–27%) and recovery (17–23%), producing isolates with high purity (85–91%) and solubility (74–94%). FTIR analysis revealed structural rearrangements, with decreased intermolecular β-sheets and increased α-helix content, while compositional analysis indicated a relative enrichment in hydrophobic amino acids, features consistent with enhanced interfacial

activity. Mineral content analysis confirmed the high food safety of the isolates, with heavy metal concentrations below the limit of quantification.

Functionally, the structural modifications induced by ultrasound translated into improved interfacial performance. Model oil-in-water emulsions were prepared by homogenizing 1% (w/v) protein solutions with 5% (v/v) oil. All emulsions stabilized by the isolates maintained excellent electrostatic stability (ζ-potential ≈ –30 mV) over 10 days. Moreover, US-treated proteins generated significantly finer emulsions, with an average droplet size of approximately 0.60 μm compared with 0.81 μm in the ST-treated, reflecting their superior stabilizing capacity and enhanced exposure of hydrophobic residues. Overall, the isolates demonstrated promising emulsifying performance and stability for food applications. Emulsifying properties and stability will be explored by image analysis (CLSM and cryo-TEM) and discussed during the presentation.

These results highlight the suitability and potential of black chickpea protein isolates as hydrocolloids in the development of plant-based food products.

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[1219] Encapsulation to interface engineering of hydrocolloids for optimal nutrition design and functional food applications

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The rational design of hydrocolloids offers powerful opportunities to enhance the stability, bioavailability, and controlled delivery of nutritionally relevant bioactive compounds while simultaneously tailoring food structure and functionality. This work integrates advances in biopolymer-based encapsulation and starch surface engineering to demonstrate how molecular- and meso-scale hydrocolloid design can be leveraged for next-generation functional foods and nutraceutical systems.

By employing protein-polysaccharide complex coacervation and ionic gelation to encapsulate polyphenol-rich plant extracts, key challenges related to degradation, poor thermal stability, and limited gastrointestinal availability were addressed. In one approach, anthocyanins extracted from black rice bran were microencapsulated using a gelatin-acacia gum double-emulsion complex coacervation system. High encapsulation efficiencies (~73–84%) were achieved across a range of polymer concentrations and pH conditions, producing spherical, compact microcapsules with smooth surfaces and enhanced thermal resistance. Differential thermal analysis confirmed improved thermostability, while storage studies demonstrated superior anthocyanin retention under both refrigerated and ambient conditions, highlighting the effectiveness of coacervated hydrocolloid matrices as protective nutraceutical carriers.

Complementarily, alginate-based ionic gelation was optimized to encapsulate phenolic compounds from *Phlogacanthus thyrsiflorus* flower extract. Response surface methodology identified sodium alginate (3% w/v) and calcium chloride (5% w/v) as optimal conditions for maximizing phenolic encapsulation efficiency. Encapsulated systems exhibited enhanced total phenolic content and antioxidant activity relative to crude extracts. Importantly, *in vitro* gastrointestinal digestion revealed a biphasic release profile, characterized by rapid initial diffusion followed by sustained release during the intestinal phase. Encapsulation effectively protected phenolics from acidic degradation and prolonged their intestinal availability, underscoring the role of hydrocolloid networks in regulating digestive release kinetics.

Beyond encapsulation, innovative hydrocolloid design was extended to starch systems through molecular-scale surface engineering using soluble amylose chains. Starch is a ubiquitous food hydrocolloid whose functionality is governed by gelatinisation and retrogradation, transitions that strongly influence texture, process tolerance, digestibility, and shelf stability. Soluble amylose chains with controlled degrees of polymerisation (DP 186–4020), generated via enzymatic debranching of amylopectin, were shown to spontaneously adsorb onto waxy corn starch granules from aqueous media. This adsorption forms a hydrated, V-type-like amylose envelope that restricts water ingress and granular swelling, increasing gelatinisation onset temperatures by up to 10 °C and altering pasting and short-term retrogradation behaviour in a concentration- and DP-dependent manner. Amylose chains within a critical DP window (~200–700) produced the most pronounced effects, indicating that chain flexibility and entropic factors govern starch-amylose interactions. This previously undocumented mechanism demonstrates that starch functionality can be tuned through non-covalent, self-assembled hydrocolloid coatings.

Collectively, these studies illustrate how innovative hydrocolloid architectures – from complex coacervates and ionically crosslinked gels to adsorbed polysaccharide coatings – can protect bioactives, regulate gastrointestinal release, and engineer food structure with nutritional and processing benefits. By integrating encapsulation strategies with interface-driven starch modification, this work provides new design principles for delivering optimal nutrition and developing resilient, functional food systems with potential applications extending to edible coatings and biomaterials.

Keywords: Hydrocolloid design; coacervated microcapsules; bioactive encapsulation; Starch surface engineering

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[1220] Emulsifier-Free Stabilization of Low-Fat Whipped Cream via Clean-Label Starch–Hydrocolloid Network Engineering

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Whipping cream, typically containing 35%-40% milkfat, is a complex oil-in-water emulsion system that transforms into aerated dairy foam upon whipping. Adequate whipping performance and product quality depend on controlled viscosity, efficient air incorporation, desirable sensory properties, and stability during refrigerated and freeze–thaw storage. In low-fat whipped cream systems (<30% fat), emulsifiers are commonly employed to promote partial fat destabilization, which in turn stabilize air bubbles. However, emulsifiers such as lactylated monoglycerides, sodium stearoyl lactylate, mono- and diglycerides, and polysorbate 80 are increasingly excluded from formulations due to clean-label considerations. This would lead to prolonged whipping time or inadequate whipping, resulting in a soft texture and poor shelf stability, resulting in an unpleasant eating experience.

To overcome these limitations, this study proposes an emulsifier-free, clean-label formulation strategy based on the synergistic structuring effects of starch and selected hydrocolloids. The resulting starch–hydrocolloid network structures compensate for reduced fat content by providing the suitable continuous-phase viscosity, supporting air bubble stabilization, and improving foam resilience (Figure 1). This approach enables the development of clean-label whipped cream formulations containing 15–25% fat with improved whipping performance, enhanced refrigerated and freeze–thaw stability, and an improvement in fatty mouthfeel. These findings highlight the critical role of starch–hydrocolloid interactions in enabling successful clean-label reformulation of aerated dairy systems.

Figure 1: Schematic illustration of full-fat whipped cream and low-fat whipped cream stabilised by a network structure

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[1008] Safe and Functional Red Algal Polysaccharide Funoran for Gut Health Applications

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Gloiopeltis furcata is a major natural source of funoran, an agaran-type sulfated galactan. The primary repeating unit of funoran, **G6S**–**LA** (β-D-galactose-6-sulfate–3,6-anhydro-α-L-galactose), underlies its distinctive structural and functional characteristics. Due to its moderate gel strength, flexibility, and high biocompatibility, funoran serves as a promising hydrocolloid for texture modification, stabilization, and incorporation into functional food systems.

Funoran was isolated through a sequential cascade extraction process, followed by partial depolymerization via controlled auto-hydrolysis. The molecular weight distribution and structural characteristics of both native and depolymerized polysaccharides were analyzed using size-exclusion chromatography (SEC), FTIR, and NMR spectroscopy. Caco-2 cell assays revealed no cytotoxic effects upon treatment with either native or depolymerized funoran. The gene and protein expression levels of tight junction markers (Claudin-1, Occludin, and ZO-1) remained comparable to the control group, indicating that epithelial barrier integrity was preserved during polymer exposure. In contrast, cells treated with dextran sulfate sodium (DSS) showed markedly reduced expression of these tight junction proteins. Cholesterol, which is essential for maintaining intestinal tight junctions, was also significantly decreased in DSS-treated cells, while its level remained unchanged in funoran-treated cells, similar to the control group. Interestingly, the partially depolymerized funoran exhibited stronger inhibition of intestinal pathogenic bacterial growth and promoted the proliferation of probiotic bacteria more effectively than the native polymer. In vivo studies in mice demonstrated that oral administration of both native and depolymerized funoran solutions caused no observable toxicity, confirming their safety for potential food and therapeutic applications. In a DSS-induced colitis mouse model, funoran—particularly the depolymerized form—effectively prevented colon shrinkage typically seen in DSS-treated mice. Similarly, spleen enlargement associated with inflammation was alleviated in DSS-treated groups, where spleen size funoran-treated groups remaining comparable to healthy controls. Moreover, the serum concentration of the pro-inflammatory cytokine TNF-α and the expression of myeloperoxidase (MPO), a marker of inflammation, were significantly reduced in funoran-treated mice compared to DSS controls. Collectively, these results suggest that sulfated polysaccharides like funoran possess notable anti-inflammatory and gut-protective properties, with molecular weight playing a crucial role in modulating immune responses in intestinal systems.

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[1009]High-internal-phase Pickering emulsions stabilized by aggregates isolated from *Agaricus bisporus* wastes

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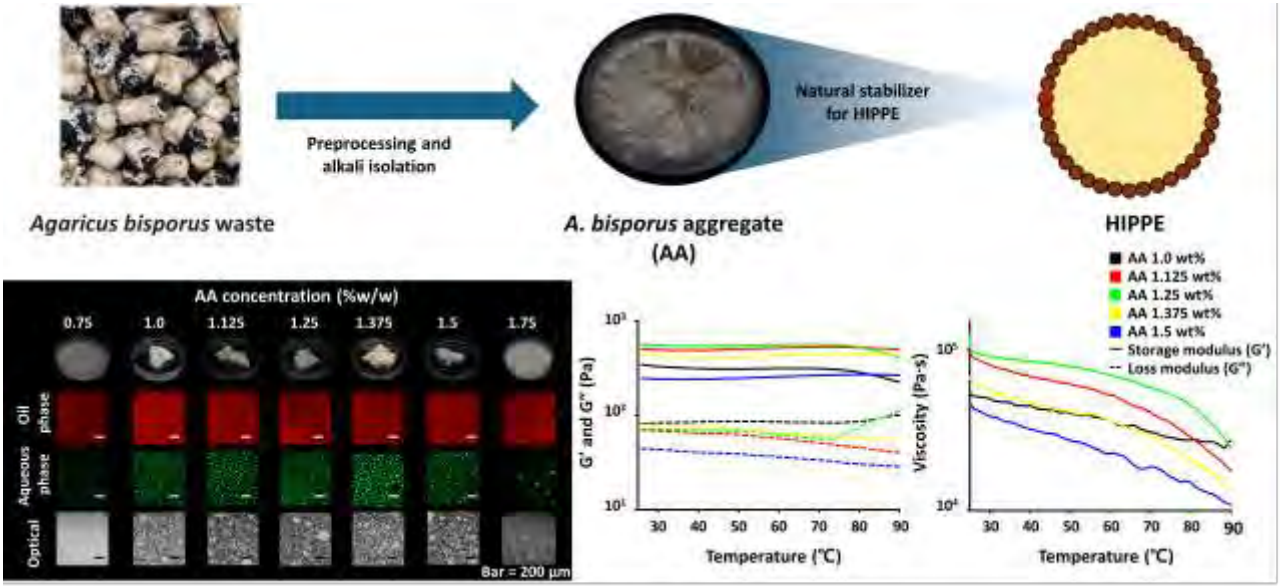
The investigation of high-internal-phase Pickering emulsions (HIPPEs) by food scientists has been motivated by their remarkable structural stability, which has significant implications for the development of innovative food textures and the delivery of lipophilic components. The development of sustainable food-grade stabilizers has proven to be a persistent challenge in the context of the HIPPE system in the food industry. In this study, *Agaricus bisporus* aggregates (AAs), derived from the wastes through preprocessing and alkali isolation, were evaluated for their potential as a natural stabilizer for HIPPEs. Stable HIPPEs were prepared with AAs in a range of 1.00–1.50%w/w. In contrast, HIPPEs were not prepared with insufficient (0.75%w/w) and excessive (1.75%w/w) AAs, resulting from incomplete and overload interfacial coverage, respectively. In the stably prepared HIPPEs, it was confirmed that the uniform size distribution of oil droplets was attributable to effective AA adsorption at the oil-water interface. Furthermore, it was observed that all stable HIPPE formulations exhibited gel-like behavior, with G′ consistently exceeding G″. It is noteworthy that the HIPPE prepared with 1.25%w/w AA exhibited the most pronounced viscoelasticity and thermal resistance (25–90°C), indicative of a robust interfacial network. These findings demonstrate the viability of AAs as a sustainable HIPPE stabilizer and provide insights into the rational design of stable food structures.



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[1010] Characterization of *Citrus unshiu* waste-isolated pectins and high-internal-phase Pickering emulsification using the

pectin aggregates with soy protein isolate

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The objective of this study was to extract and characterize pectins from diverse waste fractions of *Citrus unshiu*, which were aggregated with soy protein isolate and utilized to stabilize the oil droplets as high-internal-phase Pickering particles. All pectins extracted from flavedo, albedo, and pomace (extraction yield: 14.22, 17.56, and 14.33%, respectively) were found to be low-methoxyl with degrees of esterification of 27.40, 28.79, and 36.28%, respectively. Furthermore, all pectins exhibited shear-thinning behavior, with consistency index values of 5.13, 0.79, and 0.47 Pa·s for flavedo, albedo, and pomace, respectively. The average molecular weights were determined as 72, 29, and 7.4 kDa, respectively, based on the observed viscous behaviors. It is noteworthy that flavedo-extracted pectin demonstrated the highest dislocation density and glass-transition temperature among all the anmorphous pectins, a phenomenon that may be ascribed to its elevated calcium ion content (9.63 mg/g) and ionic interactions. The pectins were aggregated with soy protein isolate (SPI) at pH 3.5 and 4.0 through ionic and hydrogen interactions, and utilized to prepare high-internal-phase Pickering emulsions (HIPPEs). The HIPPEs that were stabilized with these aggregates demonstrated superior centrifugal and storage stabilities, with no phase separation, in comparison to those stabilized solely with either SPI or pectin. Consequently, the results suggest that pectins originating from *Citrus unshiu* waste have the potential to be used as a food additive, such as a stabilizer or emulsifier.

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[1019] Bioactivities of native and low molecular weight hybrid polysaccharide from the edible *Vertebrata lanosa*

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The bioactivities of polysaccharides isolated from the edible epiphyte *Vertebrata lanosa* and their respective low-molecular-weight (LMW) biopolymers were investigated in this study. A sequential extraction procedure was carried out on ethanol-treated and non-treated algae biomass to yield polysaccharides of a hybrid nature, containing two agaran-type polysaccharides, namely funoran and porphyran. The molecular weights of native polysaccharides ranged from 500 to 5520 kDa. Selected native samples were further subjected to ultrasonication (60–180 min) to yield LMW fractions ranging from 62 to 131 kDa. A comparative analysis between the ethanol-treated (B1) and non-treated (B2) samples revealed variations in the molecular weights of native polysaccharides with influence from the respective extraction conditions. The different antioxidant assays further showed a synergistic effect of molecular weight, sulfate, and sugar acids on the capacity of both native and depolymerized samples. A significantly high neutralization efficiency against hydroxyl radicals (up to 95%) was recorded in LMW samples. The inhibition of α-glucosidase enzyme by the tested samples was shown to be highest in the LMW polysaccharides prepared using room temperature extracted fractions. In vitro assays using selected native fractions showed no cellular toxicity on RAW264.7 macrophages using 0.5–32 µg/mL polysaccharide concentration. A trend that indicated influences of the pre-ethanol treatment and the type of precipitant used was also observed in the amounts of nitric oxide (NO) produced. Overall, produced NO in comparison to LPS was recorded in amounts that indicated immunomodulatory effects. Additionally, the treated cells recorded phagocytosis effect which highly varied in comparison with indicates a stimulatory effect on macrophages. These findings have in all, shown different levels of bioactive effects of the hybrid agaran isolated from *V. lanosa* and its potential application for nutraceutical related applications.

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[1035] From bonds to bite: linking multiscale structure and texture of meat and plant-based meat analogues.

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Replicating the complex bite and texture of meat remains a major challenge for plant-based meat analogues, as these depend on a multiscale structure and often differ in their fracture behaviour. In this study, we applied a multiscale structural–textural approach that integrates (i) molecular interactions, (ii) meso-scale architecture, and (iii) macroscopic fracture behaviour to compare meat with three plant-based analogues produced by extrusion, 3D printing, and a newly developed dry spinning method.

Dry spinning represents a promising bottom-up strategy to replicate the hierarchical organization of meat fibers, offering finer structural control and fiber alignment than conventional methods such as extrusion or 3D printing, while maintaining potential for scalability. To evaluate these approaches, we combined mechanical testing with microstructural characterization. In this way, we linked the different processing methods directly to variations in structural hierarchy and fracture behaviour.

At the macro scale, texture profile analysis and dynamic mechanical analysis in compression revealed that meat analogues were generally more anisotropic and viscoelastic than meat. Fiber orientation and interfiber connection played a decisive role for anisotropy and in fracture behaviour. Scanning electron microscopy imaging supported the mechanical data and identified sample-specific fracture patterns. Among the analogues, the dry-spun sample showed the lowest anisotropy and a more homogeneous deformation, indicating stronger and more uniform interfiber connections that resisted localized fracture.
At the meso scale, large amplitude oscillatory shear characterized the storage, and loss moduli, dissipation ratio, and strain-stiffening behavior. Meat showed a short linear viscoelastic region, low dissipation, and gradual stiffening, reflecting a stable, hierarchically organized network. Meat analogues displayed extended linear viscoelastic region ranges, higher dissipation, and earlier onset of plastic deformation, with differences strongly linked to processing technique. The dry-spun analogue exhibited the shortest linear viscoelastic region but maintained an almost isotropic response, like meat. At the micro scale, temperature-dependent small amplitude oscillatory shear confirmed that meat underwent classical thermally induced gelation. In contrast, most analogues were thermally pre-set and showed lower responsiveness to temperature changes. Protein solubility tests in selective solvents showed that meat networks involved a combination of hydrophobic, electrostatic, and disulfide interactions, while the meat analogues were mainly stabilized by hydrophobic interactions.

This multiscale analysis reveals how processing-driven differences at the molecular and meso scale define the macroscopic failure modes of meat analogues. The results provide a mechanistic framework for engineering plant-based products with improved bite and texture, narrowing the texture gap between meat and its analogues.

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[1037] Enhancement of active food packaging system via controlling emulsion stability in hydrogel composition employing multi-emulsifiers

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Active packaging systems designed to effectively deliver bioactive compounds to foods have been developed to maintain product quality and are the major subject of research. We developed humidity-responsive active packaging films by emulsifying lemongrass essential oil (LEO) and mixing the emulsion with polyvinyl alcohol (PVA). Because many factors affect release behavior, application-specific design is required. Among these factors, we compared release behavior across emulsifiers. Of four emulsifiers, two were mixed at controlled ratios to adjust the hydrophilic–lipophilic balance (HLB), and the amount of LEO released at each relative humidity (RH) was measured. Based on this data, we evaluated correlations between HLB, surface loading with LEO release behavior. Correlation coefficient between HLB value and LEO release behavior were 0.67 at 30% RH, 0.54 at 60% RH, and between surface loading value and LEO release behavior were 0.50 at 30%RH, 0.24 at 60% RH. In RH 90%, most of the LEO are released, so they are not significantly affected by these factors. When surface loading was expressed as moles of emulsion per unit area ($mol \cdot m^{-2}$) rather than mass per unit area ($g \cdot m^{-2}$), its correlation with release strengthened, correlation coefficients of 0.77, 0.55, and 0.34 respectively. To interpret these results, we modeled the droplet interface as a geodesic sphere with equilateral triangle, placing emulsifier molecules at the centers of the faces' incircles, and quantified several geometric parameters under this assumption. It suggests that larger intermolecular spacing lowers emulsion stability, facilitating droplet coalescence and collapse. These results identify a new factor that can serve as an additional stability index along with HLB and surface-loading values.

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[1038] pH-responsiveness and environmental stability of chondroitin sulfate and chitosan nanocapsules encapsulating fish oil for wound healing

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Fish oil is rich in nutrients such as omega-3 polyunsaturated fatty acids, which play vital roles in human health, but is highly susceptible to oxidation and rancidity. In this study, chitosan (ChI) and chondroitin sulfate (ChS) were combined through electrostatic interaction to form stable nanocapsules for encapsulating fish oil (ChS-ChI@FO NCs) to enhance stability of fish oil. The nanocapsules were evaluated for their various properties and their responsiveness under different conditions. The encapsulation of fish oil in nanocapsules was confirmed by XRD and FTIR analysis and encapsulation efficiency and loading capacity of 37.56% and 16.37% were achieved, respectively. The particle size of ChS-ChI@FO and ChS-ChI nanocapsules was found to increase significantly at pH 6.0 buffer solution. The release of fish oil was gradual at pH 7.4, reaching approximately 56% after 24 h. ChS-ChI@FO NCs exhibited a significantly enhanced antioxidant and antibacterial ability. ChS-ChI@FO nanocapsules were able to protect fish oil from oxidation at both room temperature and 50 °C for 4 weeks. In addition, the ChS-ChI@FO–loaded hydrogel significantly promoted wound healing, with nearly complete epithelial regeneration observed by day 14. These findings suggest the potential future extension of nanocapsules to the nutraceutical industry or wound inflammation-related applications.

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[1039] Eco-friendly extraction of chitin from squid pens using deep eutectic solvents

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The surge in seafood consumption worldwide generates abundant by-products that can be efficiently converted into value-added products following circular bioeconomy principles. Squid pens are a rich source of β-chitin, yet conventional extraction relies on harsh chemicals. Deep eutectic solvents (DESs) offer a sustainable alternative to traditional strong acids and bases due to their biodegradability, low toxicity, and recyclability. In this study, eight DES systems based on choline chloride, potassium salts, glycerol, organic acids, and urea were evaluated for the deproteinization of squid pens. The squid pens were treated with different DESs at molar ratio of 1:2 with a solid loading of 5%, w/w, and incubated in a shaking water bath at 80 ^{o}C for 2 h. Among them, potassium carbonate: glycerol (PCG), choline chloride: urea (CCU), and choline chloride: acetic acid (CCAA) showed the maximum deproteinization efficiencies of 42.47%, 24.83% and 14.16%, respectively. Optimization of DES molar ratios revealed that PCG at a 1:8 molar ratio achieved a maximum yield 36.74% and deproteinization efficiency of 92.41%; CCU at a 1:8 molar ratio achieved a maximum yield 72.66% and deproteinization efficiency of 90.52%; CCAA at a 1:10 molar ratio achieved a maximum yield 52.68% and deproteinization efficiency of 91.31%. The recyclability of DES was also tested and the extracted chitins were analyzed using FTIR, XRD, and SEM. This approach demonstrates an eco-friendly and efficient route to valorize squid pen waste for high-purity chitin extraction with potential applications in food, health, and cosmetics.

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[1046] Modified Porous Faba Bean and Cassava Starch Obtained by Ultrasound-Assisted Enzymatic and Alcohol Alkaline: A Carrier of Curcumin

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In this study, porous starch (PS) from cassava starch (CS) and faba bean starch (FS) was prepared using ultrasound (US) as pretreatment prior to enzymatic treatment followed by alcohol alkaline treatment (GCWS) to improve properties of modified starch. The effect of

these methods on morphological, ratio of 1047/1022 spectra by FTIR, thermal properties, particle size distribution, solubility and adsorption capacity were studied and compared. The result showed that the surface of PS presented rough surface with small pores on the surface of both starch granules. US-PS and US-PS-GCWS modified samples showed more porous structure on the surface especially observed on CS. The modified PS samples displayed altered significant reduced in relative crystallinity (44.23% - 20.56% reduction) while maintaining their chemical structure as confirmed by FTIR analysis. Compared with unmodified PS, cold water solubility increased by 72.05% and 58.79% for US-PSC-GCWS and US-PSF-GCWS respectively. The water adsorption capacity also increased by 30.56% and 27.66% for US-PS-GCWS on both starches compared to PS alone. All modified PS samples scored higher encapsulation efficiency compared to PS with triple modification achieved highest efficiency and thermal stability for both modified starches. The findings demonstrated that triple modification (US-PS-GCWS) effectively improved the structural integrity, adsorption capacity and encapsulation efficiency of starch, highlighting its potential as a sustainable carrier for thermally sensitive bioactive compounds in functional food application.

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1058 Xanthan–galactomannan hydrogels incorporating soy protein-stabilized oil droplets for tunable texture design: Formulation and physicochemical characteristics

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Emulsion gels are promising candidates for foods designed for at-risk populations because they provide essential nutrients and facilitate safe swallowing. However, few studies have examined how the blending ratios of commonly used food hydrocolloids, xanthan gum (XG), locust bean gum (LBG), and guar gum (GG), together with calcium ions, collectively influence the structure–texture relationship in protein-stabilized emulsion gels suited for diets requiring smooth and safe swallowing. This study aimed to examine the effects of XG–LBG–GG ratio and calcium lactate (CL) addition on the textural

properties, chemical interactions, thermal behavior, and water-holding capacity of soybean protein isolate (SPI)-stabilized emulsion gels.
Nine cylindrical emulsion gel formulations (diameter: 16 mm, height: 12 mm) with various XG–LBG–GG ratios (1% w/w total) were prepared. The formulations contained 15% (w/w) dispersed oil droplets ($d_{4,3}$ = 68.3 μm) and 4% (w/w) hydrophilic SPI (bovine serum albumin standard). Texture profile analysis (TPA) and Fourier transform infrared spectroscopy (FT-IR) were performed to assess physicochemical properties. Subsequently, CL was incorporated at 0–0.2% (w/w) into a formulation that exhibited high hardness, considering the potential weakening of gel hardness by calcium lactate while maintaining low adhesiveness and high cohesiveness to facilitate swallowing. The samples were analyzed using TPA, FT-IR, differential scanning calorimetry, and syneresis measurements to investigate the effects of multivalent cations on network integrity. Two promising formulations (3:3:3 and 3:1:3), which met the Japanese Dysphagia Diet Standard for hardness, adhesiveness, and cohesiveness, were further evaluated using International Dysphagia Diet Standardization Initiative (IDDSI) testing to determine their suitability for safe swallowing.
We found that the three groups with the highest hardness had 35–60% XG and the lowest GG content, whereas the two groups with intermediate hardness also had 35–60% XG and GG levels equal to or lower than LBG. The four softest groups showed no clear XG pattern, but consistently contained the highest GG content. FT-IR analysis showed that shifts in hydrogen-bond-associated peaks did not always correlate with macroscopic hardness, indicating that molecular interactions alone cannot fully explain texture formation. Although low CL (0.05% w/w) increased gel hardness and thermal stability, possibly due to enhanced interchain crosslinking, higher concentrations (0.1% w/w) weakened gel cohesion, likely by reducing network connectivity. Additional CL (0.15–0.2% w/w) partly restored these properties, potentially through nonspecific aggregation and ionic shielding effects. Syneresis was not significantly affected by the CL level, suggesting that water molecules predominantly occupy the available carboxylate sites, thereby minimizing the impact of calcium ions.
The findings underline key formulation insights: (i) hardness can be controlled by adjusting the XG and GG contents, (ii) FT-IR molecular changes do not consistently predict bulk texture, and (iii) calcium ion effects exhibit nonlinear behavior due to competing structural contributions. An IDDSI test confirmed suitability at Levels 4–6, with the 3:3:3 ratio being particularly ideal for moderate swallowing difficulty. These results support the formulation strategies for developing nutrient-dense, cohesive, and safe foods to enhance dietary care for at-risk populations.

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[1069] Physicochemical properties of hydroxypropylated short-chain glucan aggregate

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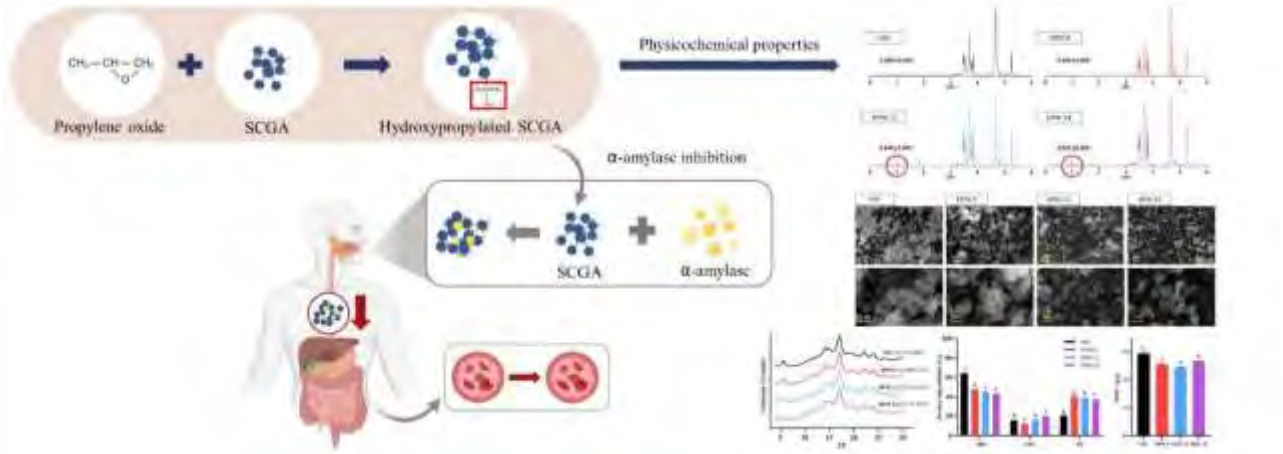

Figure 1. Schematic diagram of Physicochemical properties of hydroxypropylated short-chain glucan aggregate.

Short-chain glucan aggregate (SCGA) is a starch nanoparticle formed by self-assembly of short-chain glucans (SCGs) obtained through enzymatic debranching of starch. It is a submicron-sized particle that functions as a type of resistant starch and exhibits notable inhibitory effects on α-amylase activity. Therefore, SCGA has been studied as a promising material due to its potential to attenuate glycemic response. Hydroxypropylation (HP) is a chemical modification method that hydroxypropyl groups replace the hydroxyl groups of starch, thereby delaying starch retrogradation and increasing paste transparency. HP increases resistant starch content and enhances water retention, consequently inhibiting amylase activity. However, there have been no reports on the properties of hydroxypropylated SCGA (HPSC). Thus, this study aimed to investigate the physicochemical properties of hydroxypropylated SCGA.

SCGA was produced by gelatinizing waxy corn starch, debranching it with pullulanase, and self-assembling the resulting SCG. HP was carried out by inducing an ether bond with 0 (HPSC0), 12% (HPSC12), and 24% (HPSC24) propylene oxide at pH 11.5. The degree of substitution (DS), DSC, XRD, NMR, SEM, *in-vitro* digestibility, and α-amylase inhibition of the samples were analyzed.

Native SCGA (NSC) and HPSC0 showed no DS, whereas HPSC12 and HPSC24 revealed DS values of 0.048 and 0.092, respectively. Annealing treatment under alkaline conditions during hydroxypropylation prevented agglomeration of SCGA particles. Moreover, the structural rearrangement induced by annealing resulted in the highest enthalpy and relative crystallinity in HPSC0. However, in HPSC24, the DS was sufficiently high to offset the effects of annealing, leading to decreases in both enthalpy and relative crystallinity. These results suggest that the introduced hydroxypropyl groups in HPSC24 interfered with double-helix formation and reduced the development of crystalline

structures. Water retention capacity decreased in HPSC0 because alkaline treatment formed particles with a more ordered structure, but it showed an increase after hydroxypropylation. For *in-vitro* digestibility, all HPSC samples exhibited higher RS contents than NSC. HPSC0 showed the highest RS content, indicating that the structural reorganization caused by annealing most effectively hindered enzymatic digestion. According to a previous study, SCGA was reported to act as a competitive-type inhibitor of α-amylase. HPSC24 demonstrated the strongest α-amylase inhibitory effect, possibly due to their loosened double-helical structures leading to not only compete with the substrate but also entrap α-amylase. Overall, hydroxypropylated SCGA could enhance RS content and inhibit α-amylase activity, due to alkaline annealing and their looser structure formed by hydroxypropyl substitution, respectively. Hydroxypropylated SCGA have potential as a material capable of lowering postprandial glycemic response and can be utilized as a promising carrier for other bioactive compounds.

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[1070] Formation characteristics of 3D-printed food using sweet potato (*Ipomoea batatas* L.) starch gel

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Extrusion-based 3D food printing is a relatively new technology used to create intricate shapes layer by layer by precisely extruding a viscoelastic food material on a printing stage. The food material selected was sweet potato starch gel given that sweet potato starch is widely used as an ingredient in the food industry. However, the ability of gels to form intricate 3D shapes from initially extruded filaments has not been well studied. Therefore, this study aimed to investigate the effects of printing conditions on multilayer printing of sweet potato starch gel using an extrusion-based 3D food printer with different nozzle diameters.
We determined the printing conditions (i.e., moisture content of the gel, print temperature, print speed, and model filament width and height) appropriate for the precise extrusion of single filaments of sweet potato starch gel for each specified nozzle diameter of 1.5 mm

and 4.0 mm. When 3D food printing of square prisms with a base area of 48 mm × 48 mm was performed using precisely extruded filaments, it was necessary to perform additional 3D printing modifications (i.e., nozzle clearances for the 1st layer and succeeding layers, number of polygons per layer, and fill factor) for each nozzle diameter to improve the appearance of the 3D-printed material. As the number of layers increased, the lengths of the side of the top layer decreased gradually, whereas there was no significant difference between the lengths of the bottom layer side (p = 0.05). Consequently, the degree of flatness, which is the ratio of the length of the bottom layer to that of the top layer, increased linearly with the number of layers, illustrating the spreading of the hot gel in the top layer, whereas cooling and solidification occurred in the bottom layer. Nevertheless, it is possible to create intricate 3D shapes using sweet potato starch gel following the selected printing conditions and recommended number of layers, which are 4 and 3 for the 1.5-mm and 4.0-mm nozzles, respectively, based on the results obtained from this study.

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[1072] Effect of type of soy-based foods on their *in vitro* digestibility using a Gastric Digestion Simulator

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Various soy-based foods are being consumed in East Asia. Their texture, microstructure, and digestibility can be influenced by food processing methods. The gastric digestion simulator (GDS), which is equipped with a quantitatively simulated human gastric peristalsis, enables direct observation and analysis of the digestion behavior of food particles. The purpose of this study was to investigate the influence of processing methods on the *in vitro* gastric digestibility of soy-based foods using GDS.

Sliken tofu, koya-dofu, okara, and boiled soybeans were purchased from local markets. Silken tofu and koya-dofu were cut into 5 mm cubes. The okara was rolled into balls with diameters of 10 mm. Each boiled soybean sample was cut in half. Eighty grams of soy-based food samples were used for *in vitro* digestion experiments. Each food

sample was placed in a beaker containing 30 mL of simulated salivary fluid (SSF, pH 7.0) for 2 min. Afterwards, the mixture was introduced into the GDS vessel containing 240 mL of simulated gastric fluid (SGF, pH 1.3). The GDS experiments with simulated gastric peristalsis (1.5 cycles/min) and 0.1 M HCl addition (45 mL in total) were performed at 37 °C for 3 h. Proteins in the gastric contents sampled during the GDS experiment were analyzed using HPLC.

During the 180 min of the GDS experiments, the silken tofu particles quickly disintegrated owing to their soft and fragile texture. Koya-dofu particles with a sponge-like texture did not disintegrate as quickly as silken tofu particles. SGF was considered to penetrate the Koya-dofu particles easily and cause sudden disintegration after 120 min. As okara has a very crumbly texture, the okara bolus quickly dispersed in the GDS vessel without the disintegration of okara particles. For boiled soybean particles, most of the cotyledons disintegrated during the first 30 min, whereas the outer shell remained undigested after 180 min. The HPLC results demonstrated that the protein digestibility of the gastric contents sampled during the GDS experiments was affected by the type of soy-based food.

The use of our GDS demonstrated how the type of soy-based food affects the physical and chemical gastric digestion.

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[1077] Active food packaging: starch films with finger lime antioxidant peel extracts

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The finger lime (*Citrus australasica*), an indigenous citrus fruit native to Australia, is rich in bioactive compounds such as phenolics with strong antioxidant properties. Although often considered an agro-industrial byproduct, its peel contains substantially higher levels of phenolic compounds and antioxidant capacity than the pulp. In this study, peels from three finger lime varieties (pink, red, and green) and pulp from the red Champagne variety were freeze-dried and used to obtain antioxidant extracts through ultrasound-assisted extraction (UAE) employing 50% ethanol as solvent. The total phenolic content (TPC) was quantified, and optimal extraction conditions were determined as 30% amplitude, a solid-to-liquid ratio of 1:40, and a 5-minute treatment, yielding TPC values exceeding 300 mg GAE/sample. The optimized extract was incorporated into starch-based biopolymer films to develop active food packaging. Starch was selected due to its low cost, non-toxicity, and ease of processing, while glycerol served as a plasticizer to enhance flexibility. Films containing different concentrations of finger lime extract (5–20%) were produced and

evaluated for their physicochemical, mechanical, and optical properties. Additionally, the films were characterized for biodegradability, antioxidant activity, and total phenolic content. The formulation showing the most promising antioxidant performance was further tested for its ability to delay lipid oxidation in soybean oil samples. Overall, the incorporation of finger lime extracts into starch-based films demonstrates strong potential for developing biodegradable active packaging materials with significant antioxidant functionality, contributing to more sustainable food preservation systems.

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[1078] Preparation a sugar-sodium alginate-maltodextrin composite gel with sustained releasing properties

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A composite gel with sugar sustained-releasing property, specific designed for endurance athletes during high-intensity and long-duration competitions, was developed and its physicochemical properties and *in vitro* releasing behavior were evaluated as well. Sodium alginate (NaA) combined with maltodextrin (DE10) were used to prepare the gel matrix, which allowed to carry out high amounts of glucose and fructose to meet the requirements of at least 30g of sugar per hour for 2-3 hours. The appearance and texture of the gel made with 1% NaA and 5 mM glucono delta-lactone (GDL) were superior for other gel formulations. The addition of maltodextrin in NaA gel significantly improved the sustained-releasing effect of the composite gel, while the transparency decreased and hardness increased with increasing the amount of maltodextrin and storage time because of starch retrogradation. Although sugar-releasing behavior became slightly less stable after 1-month storage, adding high amount of DE 10 did closely meet the required sugar-releasing behavior in the first two hours. Subsequently, the sugars were continuously released due to the maltomextrins digestion through the hydrolysis of pancreatic amylases in simulated intestinal fluid to maintain the sugar level. For commercial purposes, a stable gel with good tasting characteristics and control-releasing function for a reasonable shelf-life (6 months) are critically important. Thus, the composite gel was prepared by adjusting pH to meet the low-acid food regulation by using malic acid. As a result, a composite gel made with 0.48% NaA and 22% DE 10 containing 30% sugars (glucose:fructose=2:1) with 5 mM GDL as coagulant under 14mM of malic acid solution are suitable for energy gel preparation for endurance athletes, who may consume it before competition then a stable blood glucose level can be maintained during the early stage of racing.

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[1080] Bioactive Polysaccharides from *Halymenia durvillei*: Structural Characterization and Functional Applications in Immunomodulation and Wound Healing

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Polysaccharides from algae have shown promising potential in various biomedical applications due to their biodegradability, biocompatibility, and non-toxic properties. In this study, we explored the bioactivity of polysaccharides extracted from *Halymenia durvillei* (HD, from Tomasa, Bolinao, Pangasinan) using hot (95 °C) and cold (25 °C) extraction methods. The polysaccharides were characterized by HPLC-SEC, FTIR, and ^{1}H NMR spectroscopy. We assessed their effects on cell proliferation, migration, nitric oxide production, and phagocytosis using RAW264.7 cells, as well as their impact on inflammation and wound healing in HaCaT cells. The hot-extracted polysaccharide fraction, a highly sulfated galactan. (λ-carrageenan), significantly stimulated RAW264.7 cell proliferation and migration. In contrast, the cold-extracted fraction inhibited cell proliferation at higher concentrations (0.5 µg/µL etc.) but enhanced phagocytosis activity. Furthermore, RAW264.7 cells treated with the hot extract showed a significant reduction in LPS-stimulated nitric oxide (NO) synthesis ($p<0.0001$). In wound healing assays, HaCaT cells treated with HD polysaccharides exhibited significantly faster proliferation and migration ($p<0.0001$). Caco-2 cells exposed to the polysaccharide fractions showed elevated *TGF-β1* expression and no detectable *TNF-α* expression at 24 h, indicating minimal inflammatory response and supporting their potential safety for future medical applications. Additionally, the anticoagulant activity of HD-derived polysaccharides was confirmed through an activated partial thromboplastin time (aPTT) test, showing a lower anticoagulant effect among the fractions tested. This study demonstrated that polysaccharides from *Halymenia durvillei* exhibited significant bioactivity, including promoting wound healing, enhancing immune response, and exhibiting anti-inflammatory properties. These findings suggest that HD-derived polysaccharides have potential applications in wound care, gastrointestinal health, and could be exploited in the food, cosmetic, and pharmaceutical industries.

Keywords: Carrageenan; NMR; FTIR; HPLC-SEC; Immunomodulatory; Pro-inflammatory cytokines; Anti-coagulant; wound healing.

Acknowledgment

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[1081] Molecular Weight-Dependent Bioactivities of Hydrolyzed *Chondrus crispus* Polysaccharides: Anti-Inflammatory and Colon Cancer Cell Inhibition

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Algal polysaccharides, known for their biodegradability and biocompatibility, show significant promise for biomedical applications. *Chondrus crispus* (CC), a red alga, is a rich source of these polysaccharides, and this study investigated their bioactivities following auto-hydrolytic degradation. Polysaccharides were extracted and hydrolyzed from *C. crispus*, and their molecular weight was determined using size-exclusion chromatography (SEC). Structural analysis was performed using Fourier transform infrared spectroscopy (FTIR) and proton nuclear magnetic resonance (^{1}H NMR) spectroscopy. A reduction in molecular weight after hydrolysis confirmed the successful breakdown of larger polysaccharide chains into smaller fragments. To evaluate the biological activity of the hydrolyzed polysaccharides, RAW264.7 cells were used to assess proliferation, migration, nitric oxide (NO) production, and phagocytic activity. The effects of the polysaccharide fractions were also tested on HDF, HCT-116, and Caco-2 cell lines. Specifically, the inflammatory responses in Caco-2 cells were measured by analyzing cytokine expression tumor necrosis factor-alpha (*TNF-α*), transforming growth factor-beta 1 (*TGF-β1*) and the chemokine monocyte chemoattractant protein-1 (*MCP-1*). The hydrolyzed *C. crispus* polysaccharides significantly modulated inflammatory responses and promoted wound healing, as evidenced by enhanced scratch assays. The 24-h, 50 kDa polysaccharide fraction (CC-24h) inhibited the proliferation and migration of HCT-116 (colon cancer) cells, while the native polysaccharide fraction (CC-2A) at 0.5 µg/µL had no effect on cell proliferation within 24 h. Notably, CC-derived polysaccharides resulted in a substantial reduction in LPS-stimulated NO production ($p<0.0001$) in RAW264.7 cells after 24 h. Furthermore, HDF cell proliferation was significantly increased after treatment with CC-0 polysaccharides ($p<0.0001$), which had a molecular weight of approximately 2700 kDa. In contrast, treatment of Caco-2 cells with all polysaccharide fractions led to increased TGF-β1 expression, but the absence of *TNF-α* expression at 24 h, suggesting the safety of these fractions for future biomedical applications. Additionally,

unhydrolysed polysaccharide fractions (at 0.13 μg/μL) showed no cytotoxic effects in Caco-2 cells over 24 h. These findings indicate that the bioactivity of *C. crispus*-derived polysaccharides is influenced by their molecular weight, with effects varying across different cell types. Given their potential for promoting wound healing and alleviating gastrointestinal issues, these polysaccharides have promising applications in the food, cosmetic, and pharmaceutical industries.

Keywords: Lambda carrageenan; NMR; FTIR; HPLC-SEC; Immunomodulatory; Pro-inflammatory cytokines; Anticancer.

Acknowledgment
This research was funded by Estonian Research Council grants PRG1808

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[1083] Effects of oil type and emulsion particle size on emulsion gel properties for animal fat replacement

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In this study, we investigated agar–soy protein isolate emulsion gels as plant-based fat mimics, focusing on the effects of oil type and droplet size. Emulsion gels were prepared with canola oil, rice bran oil, or eugenol in either microsized (~69–77 μm) or nanosized (~120–262 nm) forms, and their properties were systematically compared with pork fat. Nanosized emulsions produced finer and more homogeneous networks, while microsized ones showed higher mechanical strength. Rice bran oil nanosized gels exhibited balanced strength, high water-holding capacity, and low syneresis, indicating enhanced network compactness and stability. These effects were associated with phenolic components that reinforced the gel matrix. Eugenol-based gels showed a dual role of phenolics: microsized gels enhanced hardness and freeze–thaw resistance, whereas nanosized gels exhibited reduced structural integrity. Thermal analysis confirmed the absence of triglyceride melting transitions, although rice bran oil nanosized gels showed the highest transition enthalpy. FT-IR analysis revealed stronger protein–phenolic interactions in microsized gels and tighter molecular packing in nanosized ones. These findings highlight the potential of combining phenolic-rich oils with droplet-size control to design structured plant-based fats.

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[1084] Hydrocolloid-mediated mineral partitioning via intact rice in traditional Boil-Up: A culturally anchored strategy for Chronic Kidney Disease management

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Background: Chronic kidney disease (CKD) is prevalent in New Zealand and disproportionately affects Māori, underscoring the need for culturally anchored dietary strategies. CKD guidelines recommend limiting potassium to reduce hyperkalaemia risk and sodium to support blood pressure and proteinuria control. Boil-up, a traditional Māori one-pot meal of meat, root vegetables, and greens, can elevate dietary K^+ and Na^+ due to K-rich greens and salted bones. Accordingly, this study aimed to test a culturally grounded adaptation (adding intact Basmati rice in mesh bags during simmering) to harness hydrocolloid-mediated cation partitioning, reducing mineral (particularly K^+) content in the served meat/vegetable portion while preserving the dish's cultural integrity.
Methods: Standardised boil-up was prepared with intact Basmati rice (0, 30, 60, 100 g) added during the final 30 min of simmering. Minerals (K^+, Na^+, and Ca^{2+}) in the served food and recovered rice were quantified by MP-AES. Proximate composition was also measured. Data are presented as mean±SEM (n=3). One-way ANOVA with Tukey's post-hoc tested treatment effects ($p < 0.05$), with effect sizes (η^2) were reported.
Results and Mechanism: Mineral reductions scaled with rice amount ($p < 0.05$). At 100 g, for example, K^+ decreased by 40.2±2.0%, Na^+ by 53.4±1.6%, and Ca^{2+} by 39.6±8.3%, with corresponding enrichment of cooked rice. Effect sizes were large to very large, consistent with hydrocolloid-driven cation partitioning into gelatinising starch. The proximate analysis showed that carbohydrate content of the boil-up increased with increasing the rice mass, as expected. Slight decrease in crude protein was also observed, likely due to surface area-to-volume effect; i.e., each grain is exposed to a greater volume of nutrient-rich cooking water in smaller rice portions, resulting in higher nutrient absorption per gram when data is normalised to per 100 g. As grains hydrate and starch gelatinises, mineral-rich broth diffuses into the grain down a concentration gradient. The hydrated starch matrix and viscous boundary layer from surface-leached starch retard back-diffusion, enabling net $K^+/Na^+/Ca^{2+}$ transfer.
Significance: This simple, culturally compatible cooking step offers a household-level CKD strategy—substantially lowering K^+ and Na^+ exposure in the portion consumed by CKD patients while producing a nutrient-enriched rice portion for other diners. By working

within a traditional food using intact grains and boiling, it supports cultural acceptance and shared family meals without separate dishes.
Keywords: rice hydrocolloids; cation partitioning; dietary potassium; sodium reduction; traditional Māori foods; CKD nutrition.

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[1089] Effect of xanthan gum sol on *in vitro* gastrointestinal digestibility of food emulsion blends

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Food emulsions have been widely used as delivery systems for nutrients. In elderly and dysphagia diets, thickened foods containing hydrocolloids such as xanthan gum (XG) are widely used to prevent miss swallowing. These thickeners not only modify the rheological properties of liquid foods but may also influence their digestive characteristics. It is therefore important to clarify how the addition of the XG sol affects lipid digestion in emulsions. Conventional studies have mainly used monomodal emulsions, which makes precise control of lipid digestibility difficult. Recently, we proposed a food emulsion blend (FEB) prepared using two monodisperse emulsions with different droplet sizes. In this study, we investigated the *in vitro* gastrointestinal digestibility of FEBs mixed with XG sols.

Oil-in-water emulsions were prepared using 1.0% (w/w) Tween 20 aqueous solution as the continuous phase and refined soybean oil as the dispersed phase. Monodisperse emulsions were produced via premix membrane emulsification equipped with tubular Shirasu porous glass (SPG) membranes (mean pore sizes (d_p): 1.1, 10.0, and 50.4 μm). Two emulsions with different droplet sizes were mixed in equal volume to prepare FEBs. Thickened aqueous solutions were prepared by dissolving 1% or 5% (w/w) XG in Milli-Q water containing 0.05% (w/w) blue dextran and stirring for 30 min using a homomixer For *in vitro* gastric digestion, FEB (7.5 mL), thickened solution (7.5 mL), and simulated gastric fluid (15 mL) were incubated at 37 °C under shaking (115 strokes/min) for 2 h, followed by intestinal digestion with an equal volume of simulated intestinal fluid at 37 °C for 2 h. Particle size distribution and free fatty acid (FFA) release rate were measured, and droplets during digestion were observed using a fluorescence microscope.

FEBs mixed with 1% XG sol (1%XG-FEB) were macroscopically homogeneously dispersed in the simulated gastric fluid and remained as a liquid phase after gastric digestion. In contrast, the samples mixed with 5% XG sol (5%XG-FEB) did not disperse macroscopically homogeneously, and fine lumps were observed during gastric digestion. The 1%XG-FEB maintained its bimodal particle size distribution during gastric digestion. This stability was likely because of interfacial coverage by Tween 20 and XG. For the 5%XG-FEB, a new peak appeared in the 100–2000 μm range after gastric digestion, suggesting the formation of XG-derived aggregates. The distinct bimodal droplet distribution of the FEBs disappeared during intestinal digestion. FFA release profiles varied depending on the droplet size combination. In the 1%XG-FEB, the maximum FFA release after 120 min (φ_{max}) ranged from 28.6% to 39.6%, showing a positive correlation with the total droplet surface area. In contrast, in the 5%XG-FEB, φ_{max} ranged from 34.2% to 40.9%, but no correlation with surface area.

These results suggest that FEBs stabilized with a low concentration of XG have the potential to control lipid digestibility through the combined effects of droplet structure and system viscosity.

This work was partially supported by the Japan Society Grants-in-Aid for the Promotion of Science (JSPS) KAKENHI Grant Number 25K00192, Japan.

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1094 Green hydrothermal valorisation of apple pomace: co-recovery of pectin, phenolics, and sugars with development of functional dietary fibres

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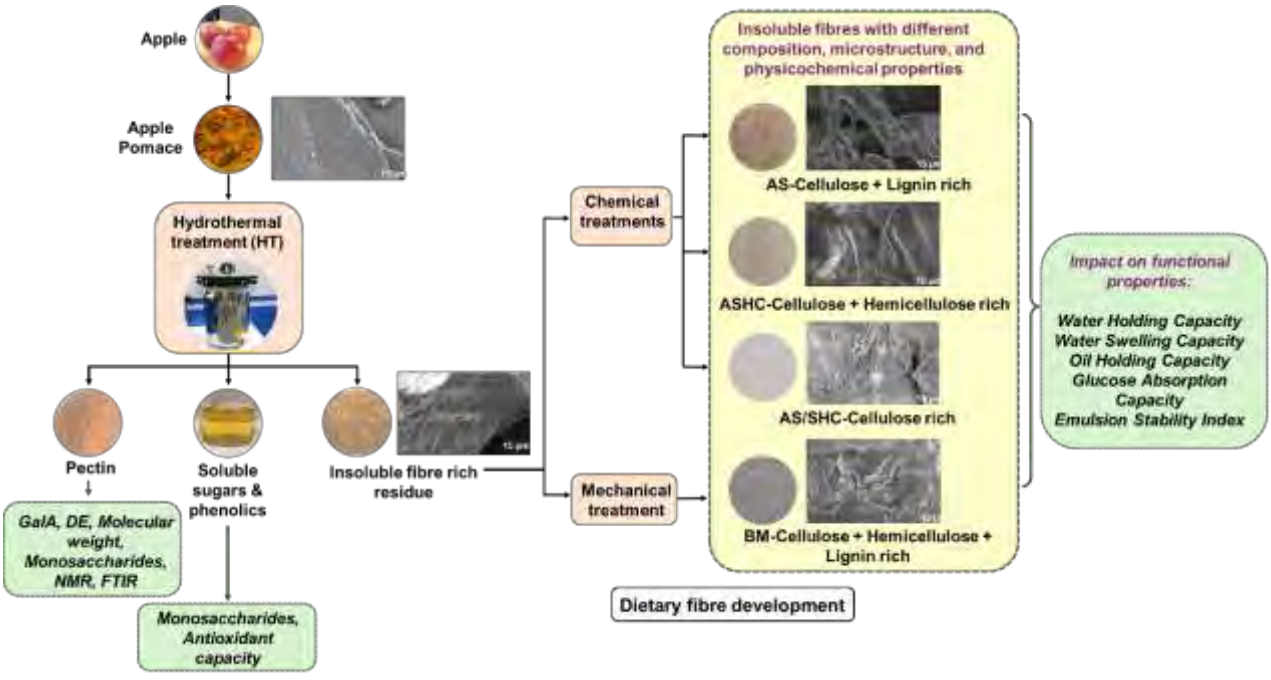
This study presents a green hydrothermal approach for simultaneously recovering pectin, phenolics, and sugars from apple pomace (AP), followed by the preparation of functional dietary fibres from the resulting fibre-rich residue. Optimised treatment at 120 °C for 15 min maximised recovery yields while maintaining phenolic antioxidant activity and minimizing pectin degradation. The extracted pectin exhibited a degree of esterification of 84.5%, uronic acid content of 83.8% and molecular weight of 161 kDa, with FTIR, ^{1}H NMR, TGA, rheology and gelling analyses confirming structural and functional characteristics comparable to commercial and acid-extracted pectin. Co-extracted

phenolic-sugar fractions were rich in glucose (92 %w/w and exhibited strong antioxidant capacity alongside a monosaccharide profile similar to conventional ethanol extracts. This sustainable hydrothermal approach enables efficient co-recovery of hydrocolloid-relevant components while reducing reliance on chemical-intensive extraction methods. Chemical (alkali, sodium hypochlorite) and mechanical (ball milling) post-treatments generated fibres with varied compositions, microstructures, and physicochemical attributes, including differences in zeta potential, particle size, and water contact angle. Chemical modifications produced cellulose-, cellulose + hemicellulose-, and cellulose + lignin-rich fibres more open microstructures, enhanced hydrophilicity, and higher surface charges relative to the compact lignocellulosic fibres generated by ball milling. Highly charged, hydrophilic, cellulose-rich fibres with thin sheet-like morphologies showed high water-holding (26.44 g/g), swelling (24.48 mL/g), and glucose adsorption capacities (11 mmol/g), whereas porous cellulose-rich fibres containing lignin and oil exhibited enhanced oil-holding capacity (19.7 g/g). Notably, hydrothermally treated fibres enriched with pectin, protein, and oil, possessed amphiphilic surfaces, small particle size, and rough morphology, which contributed to their strong emulsifying behaviour (EAI: 66.8 m2/g; ESI: 106.7 min). Overall, these findings highlight the potential of a green hydrothermal processing for producing AP-derived pectin, phenolics, and sugars, and identify key structural determinants for designing next-generation functional dietary fibres from residual biomass.

Keywords: Apple pomace; Pectin; Phenolics; Soluble sugars; Dietary fibres; Structure-function relationship, Sustainable processing



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coupled with understanding dietary fibre development via compositional, structural, and physicochemical modulations." Food Hydrocolloids 172: 112091.

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[1100] Self-gelation of xanthan gum by physical modification

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Xanthan gum (XG) is a water-soluble extracellular polysaccharide that exhibits high viscosity and pronounced shear-thinning behavior. In this study, it was found that an aqueous mixture of unmodified XG and XG modified by high-temperature and high-pressure treatment (autoclaving) forms gels after a heat–cool process. While XG has been known to interact with other polysaccharides such as locust bean gum or glucomannan to form gels, gelation induced by mixing unmodified and modified XG can present a novel mechanism.

Modified XG (XG_{AC240}) was prepared by autoclaving a 1.5 wt% XG solution at 135 °C for 240 min, followed by precipitation with isopropanol to recover. Molecular weights were determined using the size exclusion chromatography coupled with multiple-angle light scattering, whereas organic acid concentrations were quantified by the post-column detection and high-performance liquid chromatography. Rheological properties for the aqueous mixtures of unmodified and modified XG were examined on a MCR 302 rheometer before and after the heat–cool cycle, which was performed by holding the sample at 80 °C for 10 min, cooling to 10 °C at a rate of 5 °C/min, and maintaining at 10 °C for 180 min prior to the measurement of the frequency dependence of dynamic viscoelasticity in the range of 0.1–100 rad/s. Atomic force microscopy (AFM) observation was carried out using a MultiMode 8-HR in tapping mode on samples prepared by air-drying the aqueous mixtures on a mica surface.

Results showed that XG_{AC240} had a lower weight-average molecular weight (approx. 380K) compared to unmodified XG (approx. 1,600K). In addition, pyruvic acid content for XG_{AC240} decreased to 1.4 wt% from 5.9 wt% for unmodified XG. Rheological analysis revealed that both 1.5 wt% untreated XG and the mixed system for 0.75% unmodified XG and 0.75% XG_{AC240} displayed weak-gel type mechanical spectra. The mixed system exhibited lower frequency-dependence of dynamic storage modulus compared to unmodified XG, indicating more solid-like structure for the mixed system. AFM imaged the aggregations between unmodified XG and XG_{AC240}, forming the supramolecular assemblies.

These findings suggest that the gelation occurs as a result of the supramolecular cluster formation between the two components, and the resulting structure is more likely to be the fractal-like network rather than the homogeneous polymer matrix. To support this hypothesis, circular dichroism spectroscopy is currently being conducted on the modified XG. This study provides new insights into the design of xanthan-based gels through

controlled thermal modification, offering potential applications in food and material sciences.

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[1101] Physicochemical properties of dual modified rice flour by heat annealing and pressure annealing treatment

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Figure 1. Schematic diagram of physicochemical properties of dual modified rice flour by heat annealing and pressure annealing treatment.

Rice is a staple carbohydrate source widely consumed in Asian countries. However, its tendency to rapidly increase blood sugar levels has limited its broader application in food processing. Therefore, recent studies have focused on slowing digestion of rice, using physical modification methods. Heat-annealing treatment (HAT) and pressure-annealing treatment (PAT) have paid attention for their effectiveness in reducing starch digestibility and promoting health benefits. However, research on the combined effect of HAT and PAT remain limited. Therefore, effects of each modification method and its synergistic effect on the physicochemical properties of rice were investigated.

Rice flour was packed into PE pouches. The moisture content was adjusted to 70% by adding distilled water. PE pouches for HAT were annealed in a water bath at 30 °C for 24 h, while those for PAT were treated with high pressure at 150 MPa for 15 min at room temperature. The rice flour suspension was then centrifuged at 2,232 × g for 15 min. HAT-PAT and PAT-HAT were treated under the same conditions with individual treatments, with only the sequence of treatment was altered. Physicochemical properties of rice flour were analyzed using morphology, FTIR, XRD, DSC, RVA, *in-vitro* digestibility.

Under uncooked conditions, none of the treatments increased RS content compared to native rice. However, after cooking, all samples showed a decrease in SDS and an increase in RS content. In the case of single treatments, PAT resulted in a greater

increase in resistant starch (RS) than HAT. In the dual-treated samples, the HAT–PAT showed a higher RS content compared to PAT–HAT. In DSC thermal properties. HAT resulted in an increase in double helix melting enthalpy (ΔH), whereas PAT did not show a significant difference. All modified samples showed decreased ratios compared to native rice flour, indicating that short-range molecular order was partially disrupted. On the other hand, relative crystallinity (RC) increased with treatment. PAT, changes in the proportions of β-sheet and α-helix structures were observed. In RVA analysis, Peak viscosity did not show significant difference between native and modified samples. Breakdown viscosity significantly decreased in HAT, but not in PAT. Additionally, setback viscosity increased only in the PAT sample, suggesting a higher tendency for retrogradation during cooling despite the reduced stability during heating. However, when PAT was combined with HAT, it showed improved shear and heating stability, showing a reduced breakdown viscosity. In addition, setback viscosity was reduced in dual-modified samples, indicating that combining PAT with HAT altered its pasting properties. Morphological observations reveal altered aggregation and dispersion patterns of starch and protein, which influence starch-protein interactions and digestibility.

As a single treatment, HAT reduced the digestibility of rice flour by promoting the formation of double helices, thereby enhancing granular integrity and starch chain rearrangement. In contrast, PAT made the starch granules more compact and induced protein denaturation, which also led to a significant decrease in digestibility. When these two treatments were combined, the RS content reached the highest level among all samples by compensating for the limitations of each individual treatment.

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[1102] Physicochemical properties and *in vitro* digestibility of heat-moisture treated and pressure-moisture treated rice flour

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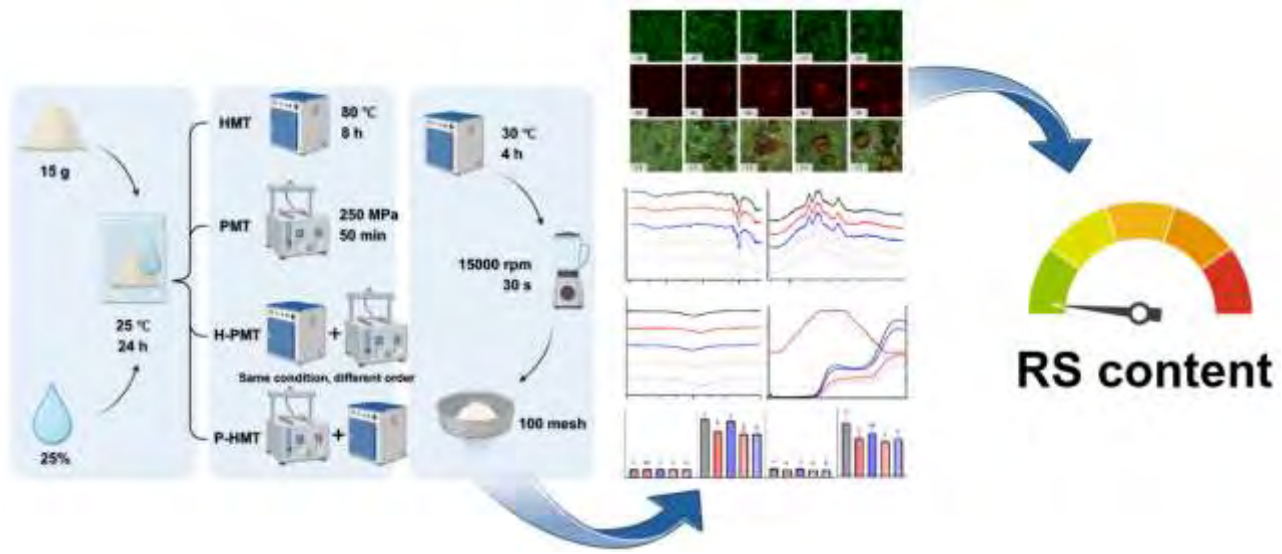

Figure 1. Schematic diagram of physicochemical properties and *in vitro* digestibility of heat-moisture treated and pressure-moisture treated rice flour.

In Asia, rice has traditionally been consumed primarily in the form of cooked rice. However, with the diversification of dietary patterns, the consumption of processed rice-based foods has been steadily increasing. Responding to this trend, efforts have been made to modify starch-based ingredients such as wheat flour and rice flour to reduce their digestibility while altering their functional properties. Among the various techniques, Heat Moisture Treatment (HMT) and Pressure Moisture Treatment (PMT) are typical physical modification methods that offer improved safety compared to chemical methods. In this study, the effects of single and dual modification using HMT and PMT on physicochemical properties and in-vitro digestibility of rice flour were investigated to provide the potential of the modified rice flour as a less digestible ingredient in processed foods.

Rice flours was placed in a polyethylene pouch, and distilled water was added to adjust the moisture content to 25% by allowing it to equilibrate for 24 h. HMT was performed at 80 ℃ for 720 min, while PMT was performed at 250 MPa for 50 min. Dual modifications were carried out HMT first and followed by PMT (H-PMT) or in the reverse order (P-HMT), using the same conditions of the previous individual treatment. Physicochemical properties of rice flour were analyzed using CLSM, FTIR, XRD, DSC, solubility, swelling power, RVA, *in-vitro* digestibility.

CLSM results showed that Both HMT and PMT induced protein aggregation, which altered the morphology of starch granules. In all modified samples, proteins were found to form large aggregates surrounding starch granules. FT-IR results confirmed that the large aggregates observed morphologically originated from protein denaturation, while the short-range molecular order of starch remained unchanged. In contrast, XRD analysis showed that the long-range molecular order was modified, suggesting rearrangement of amylopectin double helices and altered cluster packing within the granules. HMT and dual-treated samples exhibited significantly higher thermal stability compared with the native sample, whereas PMT did not show a significant difference. HMT and dual-treated samples exhibited significantly lower solubility, swelling power, and viscosity than the native sample. Digestibility behavior differed between uncooked and cooked samples.

Before cooking, protein aggregation surrounding the granules played a dominant role in limiting enzyme accessibility, whereas after cooking, the rearranged internal structures became the main factor affecting digestibility. These results demonstrate that both HMT and PMT significantly modified the morphological and structural properties of rice flour, thereby influencing its physicochemical and digestibility characteristics. Moreover, the dual treatments produced varying effects depending on the treatment sequence.

Overall, the findings suggest that physically modified rice flour produced by HMT and PMT possess potential as less digestible functional ingredients in food processing. Future studies should apply these modification methods to various rice cultivars to evaluate varietal differences and explore their potential applications in rice-based food products to assess substitutability and digestibility reduction effects.

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[1105] Development of multifunctional protein–polysaccharide complex-based emulsions, foams and emulsion gels for food applications

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Oil-in-water (O/W) emulsions are indispensable in products such as salad dressings, mayonnaise and sauces, where stability at acidic conditions is critical. Although egg yolk offers excellent emulsifying and foaming performance at acidic conditions, its use is limited by allergenicity, flavour carry-over and sustainability concerns. The present study explored xanthan gum (XG) complexes with whey protein isolate (WPI) or soy protein isolate (SPI) as natural, egg-free colloidal stabilisers functioning as emulsifiers for emulsions and emulsion gels, and investigated whether this system could stabilize foams.

At pH 4.0, electrostatic interaction between WPI and XG generated nano-assemblies (~100 nm) with a ζ-potential of –37.3 mV, compared with +6.94 mV for WPI alone. These WPI–XG complexes produced finely dispersed O/W emulsions that showed no visible creaming after 28 days at 25 °C. Cryo-SEM images revealed that the complexes adsorbed at the oil–water interface through a WPI core, while interconnected fibrillar XG structures bridged adjacent complexes to build a steric barrier layer; this characteristic architecture is considered the principal mechanism suppressing droplet coalescence in the emulsion.

SPI–XG complexes, prepared at identical acidic conditions, delivered plant-based O/W emulsions of comparable stability. Plant-based patties formulated with this emulsion gel gelled with κ-carrageenan, konjac mannan and methylcellulose also showed reduced weight loss after cooking and after frozen reheating than counterparts prepared with liquid canola oil, suggesting that oil droplets were effectively trapped within the gel matrix and

that oil leakage was efficiently controlled. These results collectively demonstrate the effectiveness of the emulsion gel as a clean-label, allergen-free fat substitute.

Furthermore, experimental results indicated that these protein–polysaccharide complexes not only improve foaming capacity but also enhance foam stability, suggesting their potential use beyond emulsion-type foods. The detailed mechanism of this effect will be examined in future studies, in which we will also investigate optimal combinations of component materials for different food matrices.

Our findings highlight the versatility of XG-mediated protein complexes as multifunctional building blocks for next-generation food hydrocolloids. By providing acid-resistant emulsification, superior foaming and robust gelation in a single system, these complexes support the development of low-protein, egg-free and plant-forward products with improved texture, sensory appeal and environmental sustainability.

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1113 Influence of pH and heat-treatment on the physicochemical, interfacial and emulsifying properties of hemp seed protein dispersions.

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The development of protein–polysaccharide conjugates via the Maillard reaction represents a promising strategy to enhance the techno-functional properties of food proteins while simultaneously incorporating bioactive or prebiotic carbohydrates. In this study, whey protein isolate (WPI) was conjugated with two distinct prebiotic carbohydrates—Inulin and galactooligosaccharides (GOS)—and the structural, functional, and interfacial characteristics of the resulting conjugates were compared. Reaction conditions were optimized to promote controlled conjugation while minimizing excessive browning. The degree of conjugation, structural modifications, and changes in molecular properties were characterized using SDS-PAGE, FTIR spectroscopy, fluorescence analysis, and browning index measurements.

Both WPI–Inulin and WPI–GOS conjugates exhibited improved solubility and thermal stability relative to native WPI, although the magnitude of these improvements differed depending on the carbohydrate type. WPI–GOS conjugates showed a higher degree of glycation, likely due to the smaller molecular size and higher reducing sugar activity of GOS, leading to more extensive protein modification. In contrast, WPI–Inulin conjugates,

characterized by lower reducing-end activity and higher molecular weight, generated less pronounced structural alterations but produced thicker conjugate layers at interfaces. Interfacial tension measurements and droplet stabilization tests revealed key functional differences: WPI–GOS conjugates displayed faster adsorption kinetics and improved emulsifying capacity, attributed to their enhanced solubility and increased hydrophilicity following glycation. WPI–Inulin conjugates, however, formed more viscoelastic and robust interfacial layers, resulting in superior resistance to coalescence and improved long-term emulsion stability. These findings demonstrate that carbohydrate size, structure, and reducing-end activity critically influence the interfacial behavior of protein–carbohydrate conjugates.
Beyond their functional performance, both conjugates provide additional prebiotic benefits. GOS conjugates deliver short-chain oligosaccharides known for selective stimulation of bifidobacteria, while Inulin conjugates incorporate longer fructans capable of modulating gut microbiota composition and enhancing fermentation profiles in the colon. The successful formation of WPI–Inulin and WPI–GOS conjugates therefore offers dual advantages: enhanced protein functionality and the integration of prebiotic components into delivery structures.
Overall, this comparative study highlights how the choice of carbohydrate significantly affects the molecular, interfacial, and techno-functional properties of WPI-based conjugates. WPI–GOS conjugates excel in improving protein solubility and rapid interfacial adsorption, whereas WPI–Inulin conjugates provide greater interfacial strength and emulsion stability. These insights support the development of next-generation prebiotic–protein conjugates for functional food emulsions, nutraceutical delivery systems, and gut-health-promoting formulations.

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[1114] Influence of pH on adsorption kinetics and interfacial rheology at the oil-water interface of *Chlorella* vs *Spirulina* Proteins: Implications for encapsulating microalgal oil

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Microalgal proteins offer promising functionality for structuring oil–water interfaces, yet their interfacial behavior under varying pH conditions—and the implications for

encapsulating microalgal-oil bioactives—remain largely unexplored. This study investigates the adsorption kinetics and interfacial rheology of protein isolates from *Chlorella vulgaris* and *Arthrospira platensis* (Spirulina) across a range of pH values relevant to food and nutraceutical applications. Interfacial tension measurements were used to quantify dynamic adsorption and film formation, while dilatational interfacial rheology provided insight into interfacial viscoelasticity and network development.
Marked differences were observed between the two protein isolates in their pH-dependent interfacial behavior. *Chlorella* proteins exhibited faster adsorption kinetics at neutral and alkaline pH, forming interfacial layers with relatively rapid reduction of interfacial tension. In contrast, *Spirulina* proteins generated more elastic and structured interfacial films, particularly near their isoelectric region, indicating stronger intermolecular interactions and enhanced film rigidity. These differences were reflected in emulsion formation and stability when encapsulating microalgal oil rich in lipophilic bioactives. Emulsions stabilized with *Spirulina* proteins showed improved oxidative protection and retention of bioactives, whereas *Chlorella*-based emulsions offered more efficient initial encapsulation due to their faster interfacial adsorption.
Overall, the results demonstrate that pH critically modulates the interfacial assembly and functional performance of microalgal proteins, influencing both droplet stabilization mechanisms and the efficiency of microalgal-oil encapsulation. These findings advance the understanding of microalgal proteins as natural emulsifiers and highlight their potential for the design of sustainable delivery systems for lipophilic bioactive compounds.

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[1116] Food-grade polyelectrolyte complex o/w emulsion microneedles enabling dual nutrient co-delivery for the patch food concept

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Hydrocolloids are emerging as multifunctional materials for next-generation food, nutrition, and health applications. However, the simultaneous delivery of hydrophilic and lipophilic nutrients within a single hydrocolloid matrix remains a fundamental challenge due to mutual incompatibility, limited mechanical strength and uncontrolled release. In this study, we developed an O/W emulsion-based dissolving microneedle (DMN) system, stabilized by food-grade polyelectrolyte complexes (PEC), for the dual transdermal delivery of ascorbic acid (AA) and lycopene (LY), supporting a novel ‘Patch-Food’ concept.

A dual-network hydrocolloid matrix was designed by combining cationic chitosan (CS) and anionic hyaluronic acid (HA), forming a PEC network acting as physical crosslinking points within the PVA/PVP continuous phase. This system enabled stable co-loading of the AA-loaded aqueous phase (PVA/PVP/HA/CS) and the LY-encapsulated oil phase at a 1:9 (O/W) ratio (pH 5). The effect of CS concentration (0–2%) on the system was investigated in depth through rheological and microstructural analyses. Furthermore, the mechanical properties TA, XRD, dissolution characteristics, *in vitro* release patterns and DPPH antioxidant activity of the fabricated DMNs were comprehensively analyzed.

Rheological analysis revealed a unique non-linear viscosity behavior (0% > 2% > 1%) dependent on CS concentration. Microscopy visually demonstrated this mechanism: 1% CS induced a 'collapse' of the existing network via PEC formation (a ball-bearing effect), drastically lowering viscosity. In contrast, 2% CS caused 'bridging' between particles, leading to aggregation (intermediate viscosity). This structural optimization led to a significant improvement in mechanical strength, doubling it from ~20 N to ~40 N and ensuring reliable skin insertion. CS-induced bridging also enhanced emulsion stability.

DMN dissolution was tunable by CS concentration: low-CS formulations exhibited rapid dissolution (~15 min), whereas PEC-reinforced DMNs dissolved over 120 minutes, enabling sustained release. *In vitro* studies confirmed a synchronized yet distinct profile: rapid AA diffusion and gradual LY release. XRD analysis confirmed both nutrients were stably dispersed in an amorphous state.

This study demonstrates that bioactive polysaccharides (CS/HA) are not mere additives but key functional materials actively controlling the rheological properties and microstructure of the O/W emulsion. Adjusting CS concentration alone allowed stability, mechanical strength and release rate to be programmed from initial burst to sustained. This approach presents high potential as a next-generation personalized nutrition delivery system, realizing the "Patch-Food" concept.

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[1119] Interface-governed physical aging in multilayer gelatin films

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Gelatin has remarkable ability to form thin films which are characterized by random molecular arrangements in a glassy state. However, when stored below the glass transition temperature, the molecular chains form helical structures (microcrystals), leading to physical aging as they shift toward a more stable state. Despite microcrystal formation, this aging negatively affects the film's strength and flexibility. To address this, we explored delaying microcrystal formation by stacking gelatin films with different isoionic points: Type A (acidic) and Type B (alkaline), creating two to five-layer structures. Each film was prepared as a 7.5% (w/v) solution with 20% glycerin added relative to gelatin weight. The films were dried at 37°C, alternately stacked, and heat-pressed to form multilayer samples. These were stored at 30°C and 50% relative humidity for 50 days, with periodic monitoring.

Physical aging was assessed through enthalpy recovery measurements using differential scanning calorimetry (DSC) and tensile tests to evaluate mechanical strength changes due to lamination.

DSC results showed that both Type A and Type B monolayers experienced gradual enthalpy recovery from day 0 to 20, a sharp increase from day 20 to 30, and deceleration approaching saturation by day 50. Type A exhibited higher recovery than Type B. In laminated films, enthalpy recovery did not follow a simple linear average of Type A and B. Instead, it declined depending on layer configuration and sequence. This irregularity is attributed to electrostatic interactions at the Type A–B interface, altering free volume distribution and helix formation, and leading to hydrogen bond reorganization and water redistribution.

Tensile tests on films with four or more layers revealed embrittlement initially, followed by ductility recovery over time. This dual-stage behavior likely results from initial free volume reduction and heterogeneous helix nucleation near interfaces, followed by the formation of a tougher, more homogeneous network through helix reorganization, interface restructuring, and water redistribution.

To better understand these thermal and mechanical changes, dynamic analyses such as dielectric relaxation measurements are needed to monitor the gelatin molecular chains' motion.

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[1120] Synergistic stabilization of W/O high internal phase emulsions (HIPEs) using a PGPR/HPMC hybrid interface within oleogel network

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This study developed a novel triple hybrid stabilization system combining minimal PGPR, hydroxypropyl methylcellulose (HPMC), and beeswax (BW) to overcome the inherent physical instability of W/O high internal phase emulsions (HIPEs). W/O HIPEs with a 75% internal phase were prepared using PGPR alone, PGPR+HPMC, PGPR+BW, and PGPR+HPMC+BW combinations, and their stability was comparatively analyzed. Synergistic effects among these components were evaluated through rheological measurements, microstructure analysis using CLSM, and centrifugal stability testing. Results showed that the PGPR-only system exhibited significant phase separation within 24 hours and low stability. The dual systems, PGPR+HPMC or PGPR+BW, demonstrated improved stability compared to the single system, but some droplet coalescence was still observed during high-speed centrifugation. Conversely, the triple system (PGPR+HPMC+BW) using all three components exhibited the highest stability, showing significantly enhanced storage modulus (G') and yield stress compared to the dual systems. CLSM analysis supported the proposed triple stabilization mechanism, where HPMC reinforces the interface from within the aqueous phase, and the BW crystal network forms in the oil phase to physically anchor the reinforced droplets. This triple system exhibited high resistance, maintaining most of its structure even under high-speed centrifugation. In conclusion, the synergistic combination of an HPMC-reinforced internal phase and the BW oleogel network is an effective strategy for producing food-grade W/O HIPEs with enhanced stability, which can be widely applied in the development of low-calorie fat substitutes and functional substance delivery systems.

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[1124] Uncovering the Role of Floridean Starch in Furcellaran Gelation

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Red algae store carbon as floridean starch, a cytosolic branched α-linked glucose polymer (Fig. 1). As an intermediate between amylopectin and glycogen—often described as “semi-amylopectin” [1, 2]. The term floridean starch originates from the red algal class Florideophyceae, where this storage glucan is abundant, though it also occurs in glaucophytes and other rhodophytes as a primary sink for carbon fixation. In species such

as *Furcellaria lumbricalis*, floridean starch accumulates in discrete cytoplasmic granules and can occupy a substantial proportion of the cell volume, distinguishing it structurally and spatially from the plastid-based starch of green plants [1, 2].

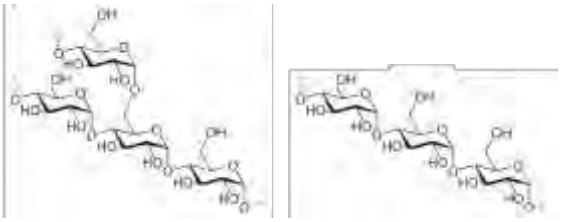

Figure 1. An example of glucose α-1-4 (A and B) and α-1-6 branching (A).

Floridean starch can account for up to 20% of the algal dry weight, and during carrageenan extraction it is commonly removed to prevent interference with the gelling performance of the sulfated galactans [3]. In this study, floridean starch isolated from *F. lumbricalis* using aqueous extraction is compared to crude extracts, purified furcellaran (β/κ-carrageenan), and their reconstructed blends. We evaluated the specific influence of floridean starch on carrageenan gelation behaviour and mechanical properties.

Floridean starch properties are characterized using spectrophotometric analysis of the starch–iodine complex and differential scanning calorimetry (DSC). The degree of branching was assessed by ^{1}H-NMR to quantify the relative proportions of α-1,4 and α-1,6 linkages, the monosaccharide composition was determined using HPAEC-PAD and the molecular weights by HPLC-SEC.

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[1125] Impact of freezing-induced glass and crystalline states in carbohydrate-protein complexes on the survival rate of probiotics

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Higher glass transition temperatures (Tg) reduce molecular mobility in dried matrices, and Tg elevation has emerged as an effective approach for improving microbial stability. Therefore, this study examined how crystalline and amorphous structures influence the survival rate of *Leuconostoc mesenteroides* throughout freezing, freeze-drying, and storage. Accordingly, whey protein isolate (WPI) was used as a protein matrix, and inulin, lactose were chosen as carbohydrate components. Each carbohydrate was individually combined with WPI. These formulations were mixed with *Leuconostoc mesenteroides* and subjected to either one-step rapid freezing at -100°C or two-step freezing at -20°C followed by -100°C prior to freeze-drying. One-step rapid freezing produced amorphous samples and two-step freezing promoted crystallization. To characterize the structural differences, appearance, X-ray diffraction (XRD), Fourier-transform infrared spectroscopy (FTIR), and differential scanning calorimetry (DSC) were performed. In addition, the survival rate during 30 days of storage was evaluated by comparing viable cell counts with those of an unfrozen control. XRD analysis confirmed the presence of crystalline structures in two-step frozen samples, whereas rapid freezing generated peak-free amorphous patterns. These structural differences were also reflected in appearance, with amorphous samples exhibiting a glossier surface than crystalline samples. FTIR confirmed these distinctions: amorphous samples exhibited broadened O–H stretching bands (3200–3500 cm^{-1}) and less-defined carbohydrate features, whereas crystalline samples showed sharp peaks indicating ordered structures. DSC demonstrated that inulin systems had higher Tg than lactose systems, and amorphous matrices consistently showed higher Tg than crystalline ones. Survival results also reflected these structural differences, with inulin formulations showing higher survival rate in amorphous glassy matrices (94% initially; 87% after 30 days) than in crystalline samples (75% initially; 66% 30 days). In lactose-based samples, amorphous matrices also maintained high survival rate (92% initially; 87% after 30 days), while crystalline matrices showed low rate (72% initially; 60% 30 days). These findings demonstrate that freezing-induced physical state and carbohydrate type determined probiotic stability, with inulin-containing amorphous matrices offering superior long-term protection.

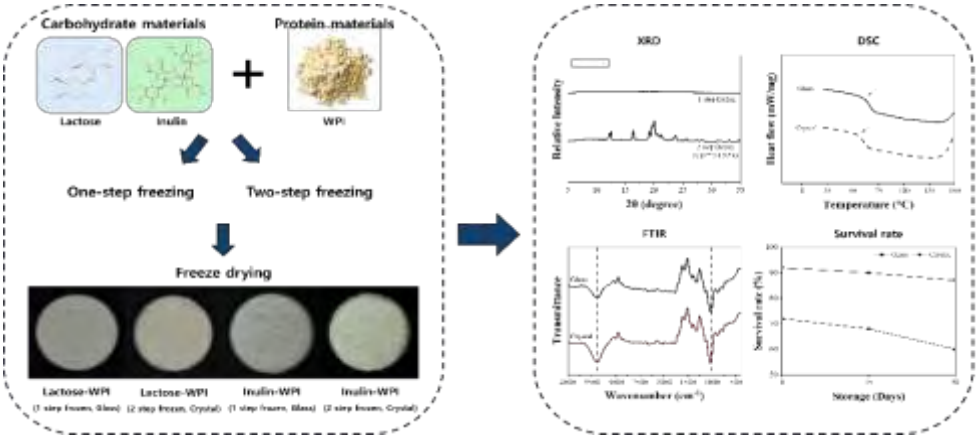

Fig.1. Overview of this study.

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[1126] Exploring algae-based hydrocolloids extracts as coatings for edible packaging solutions

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Single-use plastic packaging must be eliminated, as its impact on planetary health is huge, since it does not degrade and soon turns into microplastic particles. This has led to the development of edible and biodegradable packaging alternatives. This study presents an integrated edible packaging system that combines microalgae- and macroalgae-based components using 3D food printing technology. Edible cups were formulated using *Chlorella vulgaris* biomass and 3D-printed with a helical ridge design to increase their surface area, enhance adhesion of subsequent edible hydrocolloid coatings and reduce permeability.
Aqueous extracts of hydrocolloids from *Chondrus crispus* were used to develop the coatings, either as a control or enriched with lipid extracts or glycerol. This strategy enables the principles of 'Clean Label' to be maintained while hydrocolloids are still used as crucial ingredients.
Chemical analyses were conducted to determine the antioxidant potential (FRAP, DPPH and ABTS assays). Mechanical properties, water vapor permeability, and light barrier properties were also evaluated for the edible films.
The results showed that incorporating *C. vulgaris* added structure to the 3D 'ink', resulting in improved extrusion and better shape fidelity. This was crucial in enabling the accurate printing of the ridged cup structure. This design retained significantly more coating — over 170% more than the smooth-walled control cup. Not only did the *C. crispus* hydrocolloid coatings add a protective barrier, improving UV resistance, mechanical integrity and water permeability control, they also contributed additional antioxidant activity to the final product.
The printed matrix and the hydrocolloid-based surface coating worked synergistically to produce fully edible, nutrient-rich, functional, clean-label packaging. This work demonstrates how formulation and design can be optimised together to develop sustainable, completely biodegradable, clean-label packaging with enhanced structural and nutritional performance.

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[1127] Influence of saccharide chain lengths on the glass transition temperature and water sorption of amorphous corn starch matrices

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This study investigated the effect of saccharides with different chain lengths on the glass transition temperature (Tg) and water sorption behavior of corn starch. Glucose (monosaccharide), sucrose (disaccharide), raffinose (trisaccharide), and stachyose (tetrasaccharide) were selected. Corn starch and saccharide were mixed at 1:1 (w/w) ratio and dispersed in deionized water to obtain a 5% (w/v) suspension. The suspensions were heated at 95°C for 1 h, cooled to 25°C, frozen at -100°C, and freeze-dried. Optical microscopy analysis revealed non–uniformly shaped fragments and sheet–like structures, indicating the destruction of the crystalline structure. X-ray diffraction confirmed the amorphous structure of gelatinized starch. Water sorption behavior of corn starch-saccharide matrices was examined using the Guggenheim-Anderson-de Boer (GAB) model. The Tg of each sample was determined by differential scanning calorimetry. The effect of water content on the Tg for samples was analyzed using the Gordon-Taylor (GT) equation. Longer saccharide chain lengths were associated with a decrease in monolayer water contents and an increase in the C constant, indicating stronger monolayer binding energy compared with bulk and reduction of water mobility at the initial sorption sites. Such behavior reflects a matrix with restricted water mobility, leading to enhanced stability of the amorphous starch-saccharide systems. GT analysis revealed that systems with higher k values exhibited greater Tg sensitivity to water, reflecting enhanced water-plasticization during hydration. In contrast to the general pattern, raffinose presented a low C value while displaying a high k value, implying that hydration promotes extensive free-volume increase and thereby amplifies the Tg response to water. These combined results demonstrate that dual role of saccharide chain length in controlling both dry-state mobility and water-induced destabilization of starch-based amorphous matrices. Such insights are essential for predicting the stability of starch-based powdered products and guiding the design of starch-based products with improved functional properties.

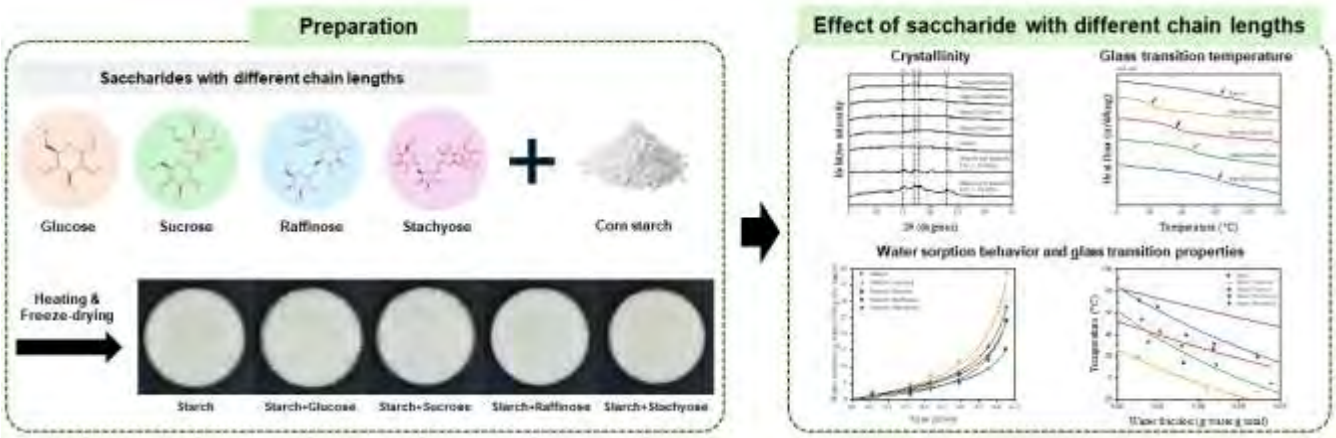
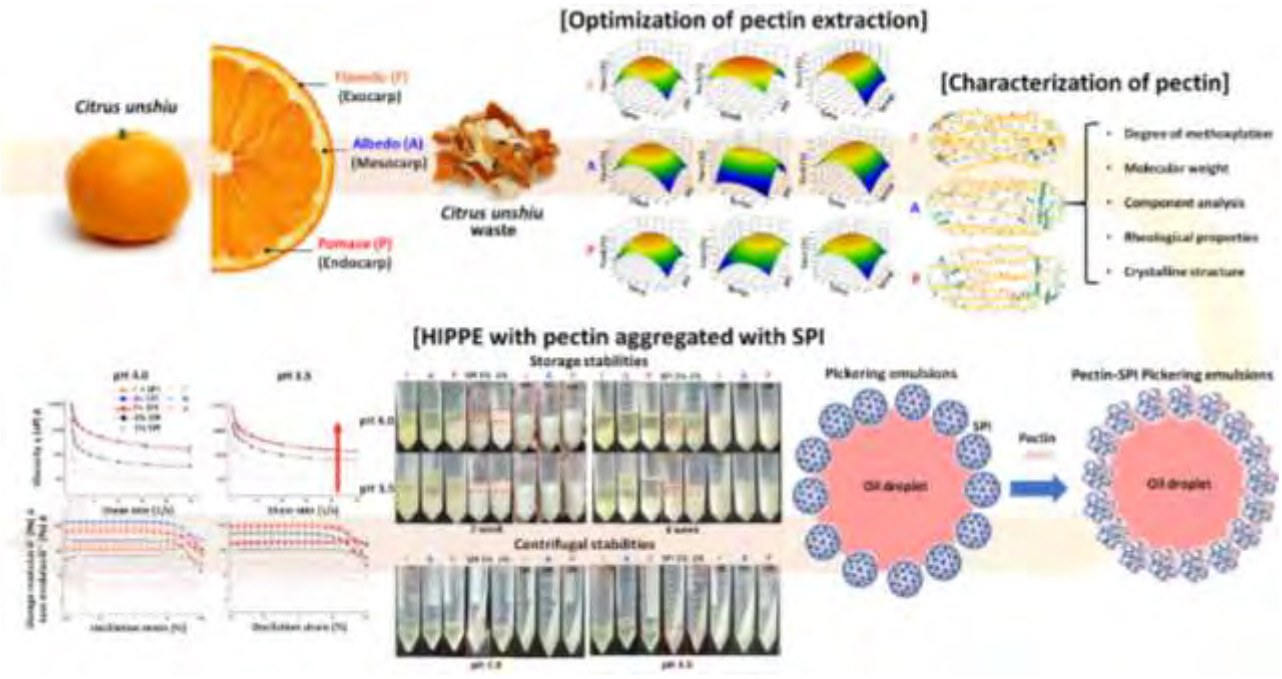


Fig. 1. Hypothesis of this study. Influence of saccharide chain length on the glass transition temperature and water sorption behavior of starch systems



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[1128] Effect of the molecular structure of the gelling agent on the gelation behavior of xyloglucan

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Xyloglucan extracted from tamarind seeds is a complex, branched polysaccharide composed of a cellulosic backbone substituted at the O6 position with side chains of α-1,6-linked xyloses, 1,2-linked β-galactoses, and occasionally α-1,2-linked fucoses. Xyloglucan has significant potential for commercial applications, particularly in the pharmaceutical and food industries, where it can be used to control drug release and modify texture. Although this polymer does not form a gel on its own, it can exhibit gelation behavior when mixed with certain small molecules, such as iodine, Congo red, Eriochrome Black T, and gallate analogs. In the present study, the gelation behavior of xyloglucan in the presence of various molecules was investigated to elucidate the underlying gelation mechanism and to identify the molecular structures responsible for inducing xyloglucan gelation.

Initially, the gelation behavior of xyloglucan was examined using gallic acid (GA) as a gelling agent. A sol–gel transition was observed in a 3.0 wt% xyloglucan solution. The sol–gel transition temperature (gel-melting temperature) was determined by the falling-ball method. Xyloglucan and GA were fully dissolved in water in a 8-mm glass tube and allowed to gel at 4 °C. A steel ball was placed on top of the gel. Upon heating, the gel eventually melted and converted to a sol, at which point the steel ball began to move downward. The temperature at which the ball started to move was defined as the gel-melting temperature.

Figure 1 shows the effect of GA concentration and solution pH on the gel-melting temperature. The gel-melting temperature increased with an increase in GA concentration, reaching approximately 60 °C. Moreover, the gel-melting temperature was higher at lower pH values (pH 4.0). Since the pKa of GA is about 4.5, the fraction of protonated acid species is high at pH 4.0, These results indicate that protonation of the carboxyl group plays a crucial role in controlling gelation behavior. In addition, the molecular structure of the gelling agent is critical for inducing xyloglucan gelation. Replacement of the aromatic ring in GA with an aliphatic chain of the same carbon number resulted in weakened gel strength. Furthermore, the relative positions of the carboxyl and hydroxyl groups were found to be key factors in determining the sol–gel transition temperature of xyloglucan.

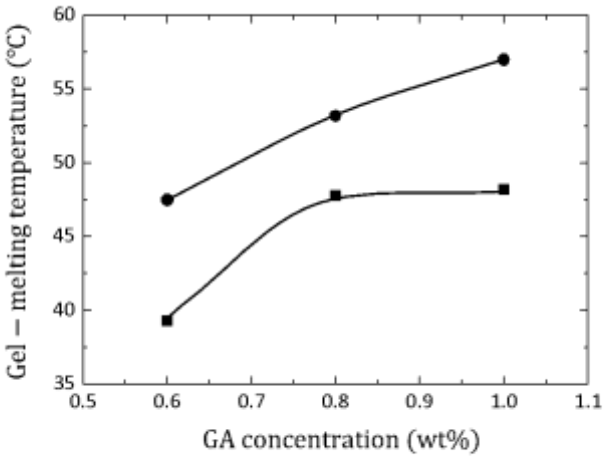

Figure 1. Effect of GA concentraion and solution pH on gel – melting temperarure.
The solution pH is (●)4.0 and (■) 5.0.

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[1129] Development of low-glycaemic white bread by substituting Thai local blend flours for optimization of texture and sensory quality.

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Bread is a staple food typically prepared with white flour which has a high glycemic index, meaning that it causes a rapid increase in postprandial blood glucose levels. This study aimed to develop a low-glycaemic index (low-GI) bread as a healthier alternative product that meets consumers expectations. This was achieved by substituting wheat flour with Thai local flours, including white bean flour, Job's tears flour and mung bean flour blended using a mixture design approach to optimize the flour composition, while rice flour and corn flour were fixed at 1:3 ratio as part of the base formulation. To improve dough structure and overcome the crumbliness observed in the preliminary non-pre-gelatinization trials, the flour blends were further modified using a Tangzhong-based pre-gelatinization technique prior to incorporation into the bread dough. Two major groups of properties were evaluated: flour properties and bread quality attributes. Flour properties included pasting characteristics (RVA), water absorption index (WAI), water solubility index (WSI), swelling power (SP), and water holding capacity (WHC), assessed for both single flours and blended formulations. The results showed the difference flour properties indicating variations in gel formation. Mung bean flour presented a high peak viscosity, final viscosity, and setback (3460 $\pm$ 16.82, 5090 $\pm$ 69.46 and 2776.33 $\pm$ 19.55) that indicated the gelatinized starch forms a highly viscous, firm and stable gels but can increase hardness in bread if used at high levels. Corn flour exhibited the highest WAI (9.28 $\pm$ 0.25) and SP (9.41$\pm$0.25), indicating strong granular expansion; however, the RVA result showed moderate final viscosity. Its gel tends to be firm but not very cohesive. Furthermore, rice flour demonstrated high final viscosity (4112 $\pm$ 31.05) and setback (2406 $\pm$ 23.06) indicating that rice starch forms a stiff and brittle gel. Conversely, white bean and Job's tears flours showed the low WAI and SP (7.87 $\pm$ 0.23 and 5.49 $\pm$ 0.56) forming weaker gels. These differences highlight the need to blend flours to balance viscosity, water interaction, and gel strength for producing bread with optimal texture and flavor. Bread quality was analyzed through texture profile analysis (TPA), loaf volume, specific volume, colour measurement, descriptive sensory analysis, and glycaemic index assessment. It was found that the addition of a pre-gelatinized blend flour, consisting of rice flour, corn flour, white bean flour, Job's tears, and mung bean at 10%, 30%, 15%, 15%, and 30%, substituting 50% of wheat flour, produced bread with enhanced texture and flavor that were acceptable by consumers. The findings provide insights into how Thai local flours and pre-gelatinization interact to influence the functional, structural, and

sensory attributes of low-GI bread, supporting their potential use in developing healthier bakery products with improved consumer acceptability.

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[1133] Sustainable Production of Cellulose from Palm Tree Biomass

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In this study, local palm tree (Sukkary) cellulose has been extracted using heating and chemical pretreatment methods. To remove lignin and hemicellulose, the date palm tree biomass (fronds) was soaked in a 2% sodium hydroxide (NaOH) solution for two hours, with stirring and heating at 80°C. The treated material was thoroughly washed with distilled water to neutralize and remove residual chemicals. A black solution resulted from the removal of lignin and hemicellulose. Bleaching was applied using sodium hypochlorite as a bleaching agent to further purify the cellulose and achieve the desired whiteness. Final washing was performed by rinsing the material again to ensure that all chemicals were removed. Drying the cellulose in an oven at 45°C for three hours to remove moisture from the isolated cellulose resulted in a dry, white fibrous form. The achieved cellulose yield was 39.2-45.3%. FTIR spectroscopy and XRD analysis were used to evaluate the purity and structural integrity of the produced cellulose. The potential applications of the extracted cellulose including the health benefits of cellulose and its role in dietary applications and the cellulose-based bioplastic for food packaging. This initiative aligns with global efforts to reduce the environmental impacts of agricultural waste and supports the transition toward renewable resources.

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[1144] Structural Characteristics and Temperature-Responsive Sequential Release Behavior of Dual-Encapsulated Flavor Oil–Seasoning Biopolymer Complexes

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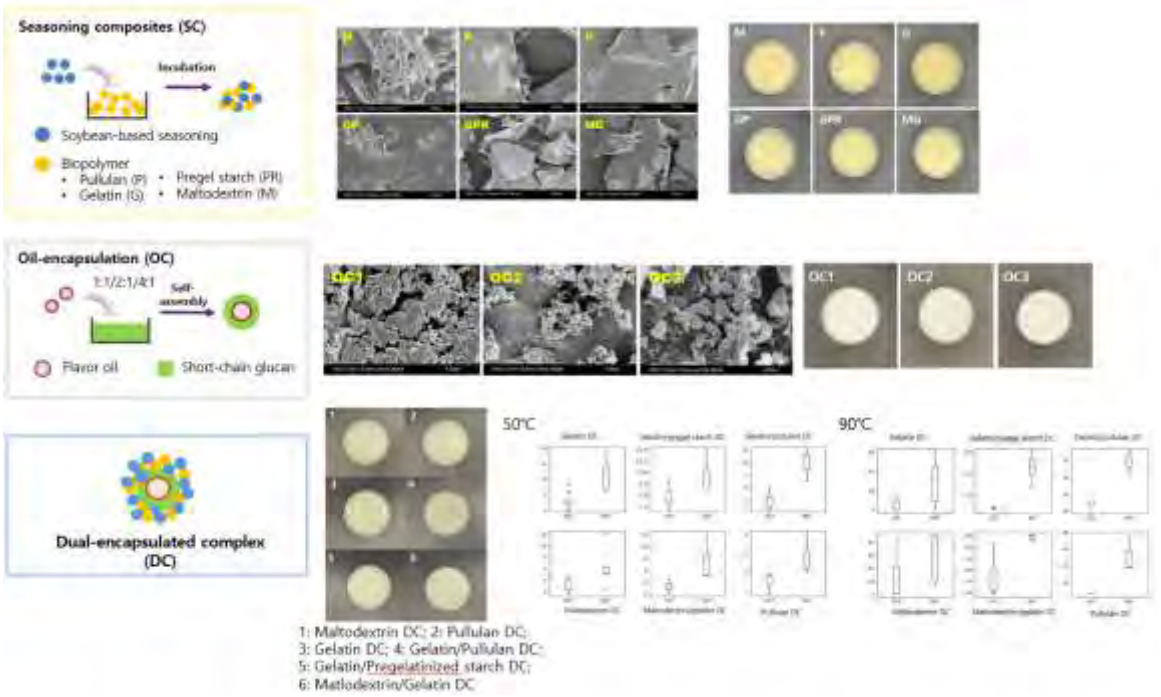
This study aimed to develop a novel biopolymer-based complex capable of dual encapsulation and temperature-responsive sequential release of flavor oils and seasoning components for food formulation applications. Hydrophilic biopolymers—pullulan, gelatin, pregelatinized starch, and maltodextrin—were used to formulate composites carrying soybean-based seasoning components (seasoning composites, SC). Separately, hydrophobic flavor oils were encapsulated using self-assembled short-chain glucan (oil-encapsulation composites, OC) and subsequently integrated with the hydrophilic matrices to form dual-encapsulated complexes (DC). Physicochemical properties, including appearance, structural features, and morphology, were characterized, and release behavior was evaluated at 50 and 90℃ using GC–MS to determine temperature-responsive and sequential release performance. SEM analysis revealed that each SC exhibited distinct microstructural characteristics depending on interactions among the constituent biopolymers. The maltodextrin SC displayed a smooth and dense surface, likely due to rapid solidification and pore formation during freeze-drying, whereas the pullulan SC showed a compact yet flexible network with partial particle aggregation. In contrast, the gelatin SC and gelatin/pullulan SC exhibited irregular and porous structures, attributable to protein–polysaccharide interactions that promoted cross-linking and pore development during drying. The OC, prepared by incorporating flavor oils with varying ratios of starch-derived ingredients, also exhibited pronounced morphological differences. The 1:1 formulation exhibited a relatively smooth surface attributable to excess oil loading, whereas increasing the proportion of starch-derived materials produced rougher surfaces with noticeable aggregated domains, suggesting that biopolymer content markedly affected oil dispersion and encapsulation efficiency. For temperature-responsive evaluation, core materials containing standard compounds were incorporated into the DC designed to disassemble at either ≥50℃ or ≥90℃, and fold changes relative to 30℃ were calculated. At 50℃, most formulations displayed significant increases in release, although the maltodextrin–oil DC exhibited unstable behavior, whereas the gelatin–oil and gelatin/pullulan–oil DC showed superior performance. At 90℃, release increased progressively, and formulations such as the gelatin/pregelatinized starch–oil, gelatin/pullulan–oil, gelatin–oil, and pullulan–oil DC met the intended design criteria by

showing minimal changes at 50℃ but pronounced increases at 90℃. Overall, the developed dual-encapsulated flavor oil–seasoning biopolymer complexes represent a promising strategy for engineering smart seasoning systems capable of temperature-triggered and stepwise release of multiple functional components. These findings underscore the potential of biopolymer-based materials as clean-label platforms for the controlled delivery of flavor constituents in next-generation food processing and formulation.



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[1153] Development of gluten-free pasta products using Thai local flour

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Pasta is a popular food consumed worldwide; however, wheat flour is its main ingredient, which poses dietary limitations for individuals with celiac disease. Celiac disease, also known as gluten-sensitive enteropathy, is increasingly being diagnosed, with a prevalence ranging from 0.7% to 2.9% of the global population. This disease is an

autoimmune enteropathy caused by gluten intolerance. Gluten is a protein found in wheat, barley, and rye. This research was aimed to develop gluten-free pasta products by using Thai local flour including rice flour, corn flour, tapioca flour, and mung bean flour. Each flour was mixed with different proportions of rice flour (30%w/w and 40%w/w) and mung bean flour (25%w/w and 35%w/w). All flours and mixed flours were analyzed for gelation properties, which included water absorption index (WAI), water solubility index (WSI), swelling power (SP) and pasting properties, using the Rapid Viscosity Analysis (RVA) method. The mixed flour was pre-gelatinized and used to replace wheat flour at levels of 0%, 50%, and 100%. The mixture of Thai local flour will be kneaded to form dough and analyzed the texture of dough before extruding using Texture Profile Analysis (TPA) and after extruding using Tensile force analysis. The results showed that the WAI of corn flour was significantly highest, followed by mung bean flour, rice flour, tapioca flour, and wheat flour, with values of 10.20 ± 0.28 g/g, 9.15 ± 0.10 g/g, 8.58 ± 0.35 g/g, 7.73 ± 0.31 g/g, and 7.67 ± 0.05 g/g, respectively. The SP was consistent with WAI, in which corn flour exhibited significantly highest followed by mung bean flour and rice flour, with values of 10.33 ± 0.29 g/g, 9.32 ± 0.10 g/g and 8.76 ± 0.35 g/g respectively. In contrast, wheat flour showed the highest WSI, demonstrating that its internal components exhibit greater water solubility. The high WAI and SP values of the flour indicate that Thai local flour performs well in gel formation, making it suitable as a substitute for wheat flour. The Thai local flour mixture provides the most suitable texture and favorable sensory properties of fettuccini by wheat flour substitution at 50%, 0%, and 100%, respectively. At a 50% substitution level, the fettuccine exhibited a yellow color with a tender and elastic texture comparable to conventional pasta. At 0% substitution, the fettuccine were yellow with a firm, chewy, al dente texture. At 100% substitution, the fettuccine were translucent white and possessed a firm, sticky, and elastic texture. It can be a substitute for wheat flour at 100% based on consumer acceptance. The replacement of wheat flour with Thai local flour can favorably be used in gluten-free fettuccine formulation.

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[1154] Effects of saccharides and polyphenols in aqueous extract of pitaya on the encapsulation of *Lactiplantibacillus plantarum*

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Pitaya (*Hylocereus* spp.) is rich in polyphenols and saccharides with health benefits, such as antioxidant and anti-inflammatory activities, and varieties can be divided into red pitaya and white pitaya based on the color of the fruit flesh. Lactic acid bacteria (LAB) as probiotics are 'live microorganisms' on the benefits for host by improving the balance of intestinal microbial flora, and have been confirmed to have the beneficial health effects including inhibition of intestinal pathogens, modulation of the immunity system, reduction

of cholesterol, and prevention of cancer. The aim of this study was to investigate the high-efficiency green extraction of bioactive compounds from whole fruit of pitaya by ultrasound (US), and effects of nutrient from aqueous extract of pitaya and US on the encapsulation of LAB. The lactic acid bacteria used in this study was *Lactiplantibacillus plantarum* FEL112, which was isolated in our laboratory. Different types of cell suspension of *L. plantarum* FEL112 with carboxymethyl cellulose (CMC), inulin, or aqueous extract of pitaya were used in the encapsulation of bacteria with capsules prepared from sodium alginate concentrations using excess calcium chloride by the extrusion method. The effects of various US durations, sodium alginate concentrations, and cell suspension liquids on the growth and β-glucosidase activity of encapsulated *L. plantarum* FEL112 were explored. The main saccharides in aqueous extract of pitaya were fructose and glucose, and the fructose contents in the aqueous extract of pitaya were between 0.2 - 0.3 g/g-extract. Furthermore, the glucose content is higher than the fructose content in aqueous extract of red pitaya or white pitaya, showing that saccharides are present in aqueous extract of pitaya to provide the carbon source for *L. plantarum* FEL112. For polyphenols, the content of chlorogenic acid was higher in the aqueous extract of white pitaya, being 7 times of that in the aqueous extract of red pitaya. The viable cell counts of the encapsulated bacteria by using inulin were 1.05 times higher than that by using CMC; however, the viable cell counts of the encapsulated bacteria by using CMC and aqueous extract of pitaya were 1.02 times higher than that by using only CMC, showing that aqueous extract of pitaya could promote the growth of *L. plantarum* FEL112 in the encapsulated state. For the bile salt tolerance, the survival for encapsulated bacteria by using CMC were higher than that using inulin in the simulated bile condition at longer time; however, regardless of whether aqueous extracts of pitaya were added, there was no significant difference in the survival for encapsulated bacteria with CMC. Besides, using CMC with aqueous extract of pitaya could greatly improve the survival for encapsulated bacteria under the simulated gastric juice condition. It could be concluded that the aqueous extract of pitaya was able to effectively enhance the stability of LAB under encapsulation as well as the added-values of pitaya in the development of health foods.

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[1155] Enhancing Pickering emulsion stability through faba bean protein isolate-dual polyphenol complexation

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1. Introduction

Pickering emulsions stabilized by plant derived particles align with clean label demands yet faba bean protein isolate (FBPI) often shows limited interfacial performance due to low solubility and compact globular structure. Non covalent interactions with polyphenols can modulate protein conformation but the cooperative effects of dual polyphenols remain insufficiently understood. This study aimed to enhance Pickering emulsion stability by forming FBPI complex nanoparticles with gallic acid (GA) as a small phenolic acid and rutin (RU) as a bulky flavonoid glycoside. The objective was to clarify how the complementary molecular characteristics of GA and RU generate cooperative structural and functional modulation of FBPI, thereby reshaping its molecular conformation, particle level properties, and interfacial assembly within a moderately unstable emulsion system with an oil volume fraction of 0.6.

2. Materials and Methods

Pretreated FBPI was mixed with GA at a fixed concentration followed by RU addition at increasing RU to GA ratios (0.0:1.0 ~ 1.0:1.0). Non covalent FBPI-RU/GA complex nanoparticles were characterized for particle size, ζ-potential, polyphenol binding content, solubility, exposed sulfhydryl (SH) and amino residues, and secondary structure. Pickering emulsions were prepared using canola oil and analyzed for droplet size ($D_{4,3}$), ζ-potential, interfacial protein adsorption, Turbiscan stability index (TSI), and microscopic features. Statistical differences were determined by analysis of variance with Duncan test at $p < 0.05$.

3. Results and Discussion

GA reduced FBPI particle size (Fig. 1A), increased solubility (Fig. 1C), and transformed disordered secondary structures into more ordered α-helix and β-sheet forms (Fig. 1F), improving dispersion and interfacial affinity. Incorporation of RU progressively increased polyphenol binding (Fig. 1B) and exposure of functional residues (Fig. 1D-E) while altering the balance between compaction and unfolding. At an intermediate RU to GA ratio of 0.4 to 1.0, nanoparticles exhibited high solubility, more negative surface charge, and a compact yet flexible secondary structure. These features enabled efficient migration to the oil water interface and formation of dense particulate films. The resulting emulsions showed smaller $D_{4,3}$, higher magnitude of ζ-potential (Fig. 1G), continuous fluorescent interfacial rings in microscopy (Fig. 1K), and the lowest TSI (Fig. 1I), reflecting strong resistance to coalescence and creaming. When RU proportion exceeded the optimal level, over unfolding and steric congestion occurred, reducing effective interfacial packing and weakening the particulate film. These effects were evident in larger $D_{4,3}$, decreased interfacial protein concentration, and increased TSI values. Collectively these findings

indicate that Pickering stabilization depends on achieving an optimal balance in FBPI structure where GA driven compaction and RU driven unfolding act cooperatively rather than independently.

4. Conclusion

Dual polyphenol complexation offers a tunable route to engineer FBPI for clean label Pickering emulsions. A GA RU ratio of 0.4 to 1.0 produced nanoparticles forming cohesive and elastic interfacial films that markedly enhanced stability, whereas excessive RU impaired assembly. This work clarifies how dual polyphenols modulate FBPI and provides a design framework for next generation plant-based stabilizers.

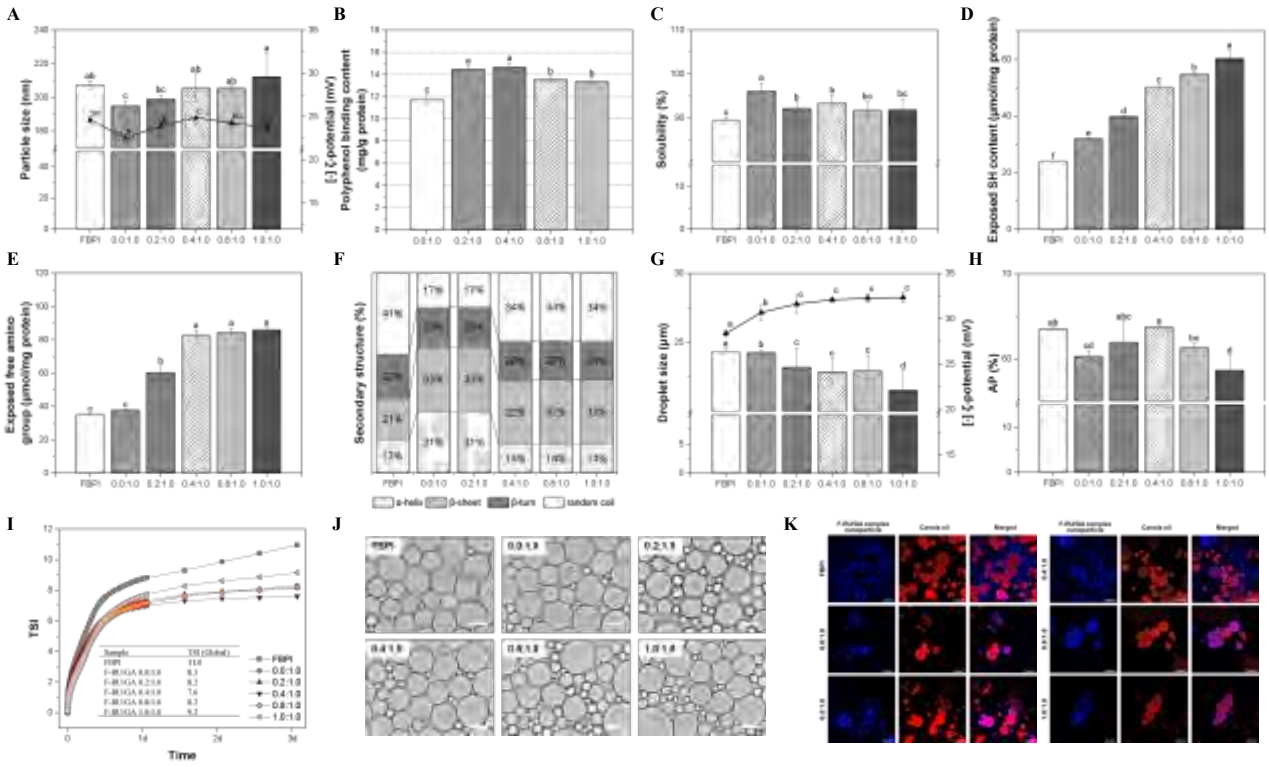

Fig. 1. Particle size and ζ-potential (A), polyphenol binding content (B), solubility (C), exposed SH group (D), exposed free amino group (E), and secondary structure of FBPI-RU/GA complex nanoparticle; droplet size and ζ-potential (G), adsorbed protein at the interface (H), Turbiscan stability index (I), optical microscopy images (J), and CLSM images of Pickering emulsions stabilized by FBPI-RU/GA complex nanoparticle. Scale bar=20 μm.

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[1161] Probing the pH-induced reconfiguration of adsorbed gelatin onto a model colloidal interface

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Gelatin is a highly versatile hydrocolloid that plays a significant role in various applications as both a gelling and emulsifying agent in the food and pharmaceutical sectors. In the food industry, the mechanisms by which gelatin stabilizes emulsions have been extensively studied. Nonetheless, the dynamic changes, specifically the reconfiguration of the gelatin layer at the interface when pH changes occur in situ, such as during gastric transit, are frequently overlooked. In this study, we aimed to establish the relationship between dynamic pH changes and the structural reconfiguration of adsorbed gelatin on a model colloidal particle using microfluidics and optical tweezers. Microfluidics allows for variation in the solution environment, while optical tweezers enable the measurement of the hydrodynamic layer thickness of adsorbed gelatin in the presence of a flow field. When a 50 ppm gelatin solution prepared at pH 8.5 (isoelectric point) was injected, a temporal increase in the hydrodynamic layer thickness was observed (Fig. 1), indicating the adsorption of gelatin. Moreover, when a low pH solution was injected, an increase in the hydrodynamic layer thickness was demonstrated. This suggests a pronounced swelling of the gelatin layer at the interface, which is attributed to an increase in the net positive charge density, enhancing electrostatic repulsion between the adsorbed polymer chains. When the solution pH was changed back to high pH, a decrease back to the original adsorbed layer thickness was observed. Thus, this study provides important insights into the structural reconfiguration of the adsorbed gelatin onto a single colloidal interface.

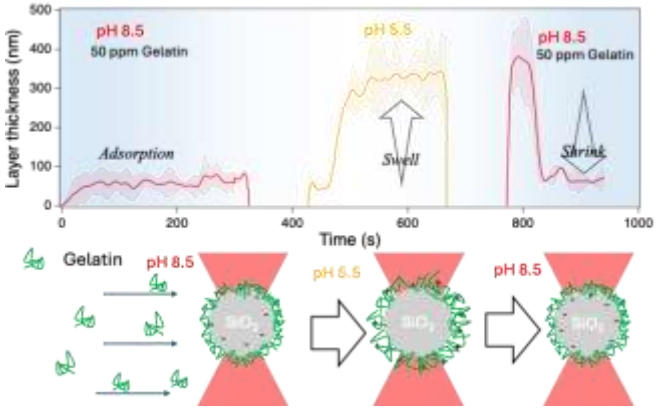

Fig. 1. Development of layer thickness during adsorption and changing pH conditions.

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[1162] Structural reinforcement of O/W bigels by incorporating soy protein isolate–gellan gum complex and beeswax: Enhancing 3D printing precision and freeze-thaw stability

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This study presents a novel strategy to enhance the freeze-thaw stability and printability of clean-label food inks by developing a complex-layer bigel (CLBG) system. In this system, soy protein isolate (SPI) and gellan gum (GEG) were used to form a complex to structure the aqueous phase, while beeswax (BW) was added to structure the oil phase through crystallization. A systematic comparative analysis between single-layer and complex-layer systems revealed that the complex-layer system, formed by electrostatic interactions and hydrogen bonding between SPI and GEG, established a robust interfacial network. This significantly improved viscoelastic properties compared to the single-layer system stabilized solely by protein. In addition, the conversion of free water into bound water was confirmed to greatly enhance the structural stability of the gel system. Notably, the dual-structuring strategy, combining aqueous phase structuring through the complex and oil phase structuring through the incorporation of beeswax (BW), further strengthened structural integrity through synergistic effects. This effectively mitigated structural damage caused by ice crystal formation during freezing, enabling the ink to stably maintain its inherent viscoelastic properties, water- and oil-holding capacities, and ζ-potential even after thawing. Consequently, color changes were suppressed to a level imperceptible to the naked eye ($\Delta E^* < 3$), despite undergoing freeze-thaw cycles. Furthermore, this system demonstrated outstanding 3D printing performance with high shape fidelity and deposition precision. Overall, the dual-structuring strategy integrating SPI-GEG complexes and wax presents a promising approach for designing freeze-thaw stable matrices for fat replacers in frozen foods and functional 3D printing applications.

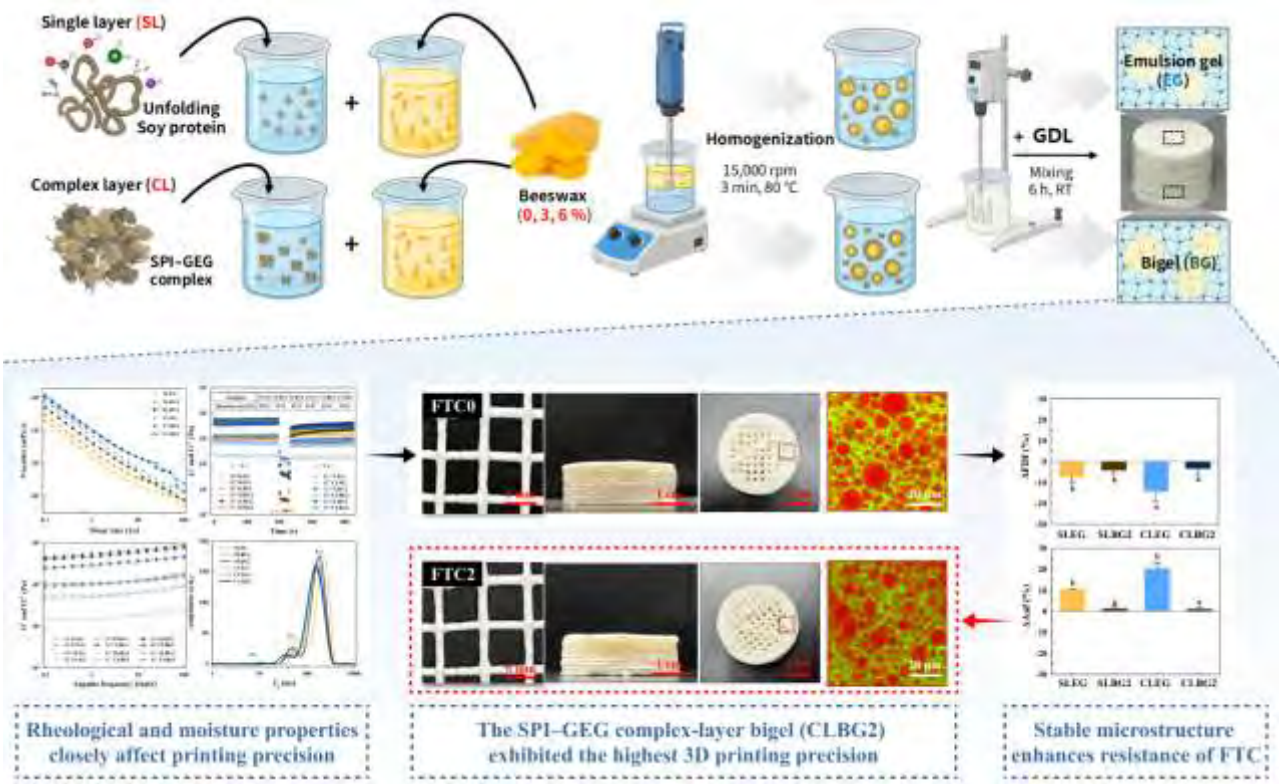

Figure 1. Fabrication process and evaluation framework for SPI-GEG complex-layer bigel (CLBG).

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[1165] Rheology of bakery products bolus – Interaction with saliva and effects of shortening and whey protein isolate (WPI)

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** Presenting author*

Food oral processing is a key stage for safe swallowing, during which ingested foods are broken down through compression and shear by teeth and tongue and then mixed with saliva to form a cohesive bolus. In this study, we prepared three model bakery crackers: control that was made from wheat flour and water, a shortening-added sample, and a WPI-added sample. The three model crackers were fragmented into granules of ~1

mm for preparing artificial boluses by subsequently impregnating the granules with an amount of artificial saliva without amylase. The mechanical strength of the saliva-absorbed granules was evaluated by a penetration test, and the bolus rheology was characterized by strain-sweep and frequency-sweep measurements. The cracker samples with added fat exhibited a brittle and weak structure compared with the control, possibly due to the disruption of the gluten network by shortening. In contrast, the WPI-added samples showed greater mechanical strength than the control, which was attributed to the reinforcement of the protein network by WPI. As a result, the fat-added sample developed a sticky surface layer after absorbing 60% saliva, as the granule surface partially broke down. This sticky layer promoted strong inter-granular adhesion. However, the WPI-added samples showed weak adhesion due to lubrication by unabsorbed saliva, as their firm structure limited saliva penetration. With increasing saliva uptake, the mechanical strength of all samples decreased, while the overall strength remained in the order WPI-added > control > fat-added. The elastic modulus (G′) obtained from rheological measurements also decreased with saliva uptake in all samples. However, at 60% saliva, the fat-added samples showed a higher G′ than the control, despite their weaker individual granules, indicating that adhesive interactions between granules contributed to the bolus elasticity. In contrast, the WPI-added samples maintained higher elasticity than the other samples at all saliva levels, reflecting their inherently greater mechanical strength. In conclusion, our study clarified how the mechanical strength of the granules and the adhesion formed between them after saliva uptake influence bolus rheology. In addition, adjusting ingredient composition can modulate these rheological properties, providing useful insights for designing bakery products with improved texture and swallowability.

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[1168] Rheological Properties of Sulfated Agarans Extracted from Different *Gloiopeltis* Species

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Funoran is a sulfated red algal polysaccharide belonging to the broader class of agarans. Although it shares certain structural features with agarose and porphyran, funoran remains comparatively under-characterized, particularly regarding its cation-mediated

structural and functional properties. In this study, funoran fractions extracted from several *Gloiopeltis* species were systematically analyzed to elucidate their structural features and physicochemical behavior as hydrocolloids. The polymers were characterized using HPLC, FTIR, ^{1}H NMR spectroscopy, rheology, and wide-angle X-ray scattering (WAXS).
^{1}H NMR analysis confirmed the primary repeating unit of funoran as **G6S–LA** (β-D-galactose-6-sulfate–3,6-anhydro-α-L-galactose). WAXS revealed that the addition of only 20 mM $BaCl_2$ induced a distinct structural transformation, evidenced by the splitting of diffraction peaks into multiple reflections. This peak separation indicates increased chain ordering and tighter molecular packing, suggesting a strong and specific interaction between Ba^{2+} ions and funoran chains.
Ion-mediated changes were also evident in rheological measurements. At 300 mM $BaCl_2$, the storage modulus (G′) increased by more than an order of magnitude compared with the control (without Ba^{2+}), reflecting a substantial enhancement in gel strength and network cohesion. This dramatic rise in viscoelasticity is consistent with the formation of strong intermolecular cross-links and a denser polymer network mediated by divalent cations.
Overall, these findings provide important new insights into the structure–function relationships of funorans and demonstrate that divalent cation modulation—particularly through Ba^{2+}—offers a powerful strategy for tailoring the rheological and structural properties of sulfated agarans for cosmetic, biomedical, and other biotechnological hydrocolloid applications.

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[1170] LbL-driven Turing-like patterning in chitosan–gelatin films: morphological control and reaction–diffusion mechanisms

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Chitosan is a naturally derived biopolymer with excellent film-forming ability, biocompatibility, and antimicrobial activity. However, its single-layer films generally suffer from insufficient thermal stability and mechanical strength, limiting their practical applications. To enhance these properties, our laboratory has explored multilayer structures by layer-by-layer (LbL) assembly methods, alternately stacking chitosan and gelatin samples[1)]. During this process, we observed that films composed of three or more layers frequently exhibit distinctive stripe-like patterns. The dimensions of these stripes

ranged from approximately 0.5 mm to 2 mm, closely resembling the skin of mackerel. The origin and implications of these patterns, however, remain largely unexplored.

In this study, we first investigated the conditions that lead to the emergence of these patterns and conducted a systematic characterization of their morphology. Acid-processed gelatin, alkali-processed gelatin, and chitosan were used to prepare 7.5% (w/v) gelatin and 2.0% (w/v) chitosan solutions containing glycerol. Films were cast at 37 °C and laminated in alternating sequences to create three-layer samples, which were stored in sealed containers at 30 °C. Stripe patterns appeared in nearly all six possible combinations of chitosan–gelatin layer arrangements, with the geometric features varying depending on the stacking order.

A literature survey suggested that these structures resemble Turing patterns arising from reaction–diffusion dynamics. To verify this possibility, we implemented simulations using the Gray–Scott model in Python. The simulated patterns showed remarkable similarity to those observed experimentally, supporting this hypothesis.
Future work will employ differential scanning calorimetry to determine whether pattern formation affects the glass transition behavior, and small-angle X-ray scattering will be used to elucidate the underlying structural organization that initiates these patterns.

1) F. Luangapai and S. Iwamoto, *Int. J. Bio. Macromolecules*, **249**, 126061(2023).

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[1172] Self-assembly mechanism of whey protein hydrolysate and α-, β-, and γ-cyclodextrin nanocomplexes for enhanced bitterness masking and colloidal stability

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This study investigated the bitterness-masking effects and physicochemical characteristics of whey protein hydrolysate (WPH) complexes with α-, β-, and γ-cyclodextrins (CDs). To evaluate the influence of cavity size and binding capacity, WPH was reacted with each CD at molar ratios of 1:0.5, 1:1, 1:1.5, 1:2, and 1:3 (M/M). Free

amino acid analysis indicated that WPH contained a high proportion of hydrophobic residues (Val, Leu, Ile, Phe), accounting for 41.6% of total amino acids, which contributed to its pronounced bitterness. Peptide sequencing (LC–MS/MS, de novo sequencing) confirmed β-lactoglobulin–derived peptides as the dominant components. Gel permeation chromatography showed an increase in molecular weight from 5.8 to 10.9 kDa after complexation, confirming inclusion formation across all CDs. Among the complexes, WPH/α-CD showed limited encapsulation ability due to its smaller cavity (K = 1.71 ± 0.52), resulting in moderate solubility improvement (78–82%) and partial bitterness reduction (~30%). β-CD exhibited the highest inclusion constant (K = 6.58 ± 1.97) and a strong decrease in UV absorption at 288 nm at low to moderate ratios (≤ WPH: β-CD 1:1.5), suggesting efficient encapsulation of aromatic residues ($p < 0.05$). However, at higher ratios (≥ WPH: β-CD 1:2), β-CD complexes showed reduced UV absorbance change and weaker amide I/II band shifts in FT-IR, likely due to aggregation-induced reduction of binding efficiency. This was accompanied by increased turbidity (0.9→1.2 a.u.) and a less negative ζ-potential (−23.7 mV), indicating decreased colloidal stability. In contrast, γ-CD complexes displayed the highest solubility (up to 92%) and the lowest Turbiscan Stability Index, maintaining stable dispersion even at higher CD ratios ($p < 0.05$). TEM images revealed that β-CD induced larger self-assembled aggregates (350–400 nm), whereas γ-CD formed uniform spherical nanoparticles (300–350 nm). Bitterness decreased proportionally with increasing CD ratios, reaching the greatest reduction at 1:2 (M/M) for all complexes. Sensory and electronic tongue analyses confirmed that β-CD reduced bitterness intensity by 50%, γ-CD by 43%, and α-CD by 30%, compared with uncomplexed WPH. α-, β-, and γ-CD showed distinct self-assembly behaviors governed by cavity size and binding densityβ-CD achieved the strongest hydrophobic inclusion and greatest bitterness masking at moderate ratios but suffered aggregation at higher concentrations. γ-CD maintained high solubility and stability, while α-CD showed weaker inclusion but consistent performance. These findings demonstrate that the self-assembly and inclusion behavior of cyclodextrin–WPH nanocomplexes are governed by cavity size, where β-CD maximizes encapsulation efficiency while γ-CD ensures structural stability, providing a molecular basis for optimizing bitterness-masking systems in protein-based food formulations.

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[1173] Study on gels formed by interaction of xyloglucan and locust bean gum

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A mixed aqueous solution of xyloglucan (XG) and locust bean gum (LBG) forms a gel when subjected to freeze-thaw cycles. While LBG alone also forms a gel after freeze-thaw treatment, mixing it with XG produces a synergistic effect, suggesting an interaction between XG and LBG. This effect has been applied in maintaining ice cream shape, and elucidating its mechanism is not elucidated yet. This study reports results using tamarind seed gum (TSG) as XG, observing gelation behavior under freeze-thaw cycles, and structurally investigating the mechanism using scanning electron microscopy (SEM) and small-angle X-ray scattering (SAXS).

TSG and LBG samples were obtained from MP Gokyo Food & Chemical Co., Ltd. SAXS measurements were performed at BL-6A of the High Energy Accelerator Research Organization (KEK).

Melting tests of frozen desserts containing XG and LBG mixtures revealed synergistic effects compared to other polysaccharides. Similar synergistic gelation effects were observed in XG and LBG mixed aqueous solutions. SEM examination of freeze-dried gels revealed a mesh-like structure. Increasing the number of freeze-thaw cycles reduced the mesh size. SAXS measurements also showed increased scattering intensity with more freeze-thaw cycles, indicating enhanced cross-linking regions.

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[1176] Tailored amylose coat on waxy corn starch for consumers with slow swallowing initiation

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Objective: Short-soluble amylose chains have been documented to form an amylose coat over waxy corn starch granules inhibiting gelatinisation and retrogradation. However, certain key questions remain unanswered viz., how does the amylose coat modulate, a) viscosity decay, and b) textural mouthfeel of coated waxy corn starch gels when subjected to simulated oral processing? This study explores these key questions under simulated consumer sensory experience with slow swallowing initiation.

Methodology: Waxy corn starch (ca. 99 % amylopectin, Amioca powder TF-04400108) and isoamylase enzyme (≥10^7 units mg^{-1} protein) were purchased from Ingredion Inc., USA and Megazyme, Ireland, respectively. Mucin type II was purchased from Sigma-Aldrich, India. Short-soluble amylose (DP_{av} ~700) was fabricated from waxy corn starch by isoamylase hydrolysis (40 °C, pH 4.0, 24 h) coupled with aqueous fractionation at 25 °C. Waxy corn starch: short-soluble amylose chain was combined in the ratio, 1:50 (parts by weight) (AP25W-3) while uncoated waxy corn starch gel was used as control. Flow curves were obtained at 37 °C, 1 to 100 s^{-1}, fitted to the Ostwald-de Waele model ($\sigma = k\dot{\gamma}^n$) where, σ is the shear stress (Pa), k is the consistency index ($Pa.s^n$), $\dot{\gamma}$ is the shear rate (s^{-1}), and n is the flow index. Changes in viscosity during simulated oral processing were registered using a starch pasting cell, adapted to a controlled stress rheometer (Anton Paar) with a Peltier concentric cylinder system to control the temperature (37 °C) while shearing (10 s^{-1}) at 37 °C for 120 s using a continuous ramp. To model the viscosity breakdown during the simulated oral digestion, viscosity data under oral conditions (constant shear and, with and without SSF+mucin) was fitted into a second order structural equation, $\frac{n_0-n_e}{n-n_e} = kt + 1$, where η is the viscosity at a given time, t is time in seconds. Symbols represent initial apparent viscosity (η_0, Pa.s), the equilibrium apparent viscosity (η_e, Pa·s), and the rate of structure breakdown (k).

Results and Conclusion: Amylose-coated waxy corn maintains an initial smoother texture (0.8 Pa.s), as compared to uncoated waxy corn (1.35 Pa.s) for oral processing without salivary α-amylase. Upon oral processing with salivary α-amylase, the amylose-coated gels retain relatively stable viscosity decay at ca. 40% breakdown while there is a rapid viscosity decay for uncoated gels at over 2× times the amylose coated rate ca. 90% breakdown. In practical terms, starchy food made with amylose-coated waxy corn could feel less “rapidly” watery during oral mastication, as studies explicitly link salivary α-amylase action to rapid in-mouth thinning, a critical window for consumers with slow swallowing initiation.
Such a design could potentially shape starchy food formulations and thickeners for slow-eating children, older adults and dysphagia patients usually with slow swallowing initiation. Hypothetically, this will assist health care providers to tweak the residual oral viscosity and achieve tailored formulations with suitable breakdown during the critical window (oral hold time), thereby reducing the risks of choking from thick or rapidly thinning foods.

Keywords. Amylose coat, Waxy corn starch, Oral processing, Viscosity decay, Slow swallowing initiation, Dysphagia

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[1185] Effects of XG/LBG gel concentration on the stability and rheological properties of G/O/G emulsions

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This study investigated the effects of incorporating xanthan gum (XG) and locust bean gum (LBG) into the inner gel phase (G_1) on the physicochemical properties of gel-in-oil-in-gel (G_1/O/G_2) emulsions, while the outer gel phase (G_2) was kept constant at 0.5%. XG and LBG were combined at a 1:1 ratio to form the G_1 gel matrix, and their concentrations were adjusted to 0, 0.3, 0.5, and 1.0%. The resulting emulsions were evaluated by visual appearance, microscopic observation, confocal laser scanning microscopy (CLSM), particle size analysis, ζ-potential, encapsulation efficiency (EE), rheological characterization, and sensory evaluation. The visual appearance of the emulsions remained uniform with no visible phase separation. Microscopic observation revealed that increasing the inner-phase gum concentration led to finer and more uniformly distributed droplets. CLSM analysis showed that the 0.5% and 1.0% formulations maintained highly stable G_1 droplets, exhibiting insignificant coalescence and strong interfacial stabilization. Particle size analysis showed that the 0% XG/LBG sample had a mean droplet size of 8.80 ± 3.90 μm, whereas the 1.0% formulation exhibited a significantly smaller size of 4.90 ± 1.90 μm ($p < 0.05$), with droplet size decreasing as the G_1 concentration increased. ζ-potential values appeared reduced in magnitude, due to the decreased electrophoretic mobility caused by the gelled outer phase (G_2) compared with conventional emulsions. Encapsulation efficiency analysis showed that the 0.5% formulation achieved the highest retention of the internal aqueous phase, exhibiting the greatest encapsulation efficiency among all samples at 98.2% ($p < 0.05$). Rheological evaluation showed shear-thinning behavior, and G′ consistently exceeded G″, confirming gel-like characteristics. Higher gum

levels strengthened the network, with 0.5% exhibiting the most balanced elasticity. Higher gum content enhanced viscoelastic stability, with the 0.5% and 1.0% formulations maintaining the highest G′ and G″ values across the frequency range, indicating the strongest network structure. The rheological increase in viscoelasticity and network strength corresponded with higher perceived thickness in sensory evaluation. Notably, bitterness intensity was reduced in the 0.5% formulation, which, among all samples, provided the best balance between structural integrity and consumer acceptability. Collectively, the results demonstrate that while increasing XG/LBG concentration enhances network strength and droplet stability, the 0.5% XG/LBG formulation provides the most favorable balance between viscoelasticity, interfacial stabilization, emulsification efficiency, and sensory quality. This gel concentration promotes efficient droplet disruption, enhances encapsulation performance, and ensures sustained structural coherence, thereby representing the optimal formulation level for achieving both physicochemical stability and consumer-preferred quality in $G_1/O/G_2$ emulsions.

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[1188] Effect of the gel state on the biological activity of scleroglucan

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Scleroglucan is a β-glucan with a β-1,3-linked main chain and β-1,6-linked side chains. It shares the same chemical structure as schizophyllan, which is well known for its antitumor activity, and scleroglucan is also recognized as a ligand for Dectin-1. The antitumor and immunomodulatory activities of β-glucans mediated by Dectin-1 have been reported to be significantly influenced by factors such as molecular weight, degree of branching, and stereochemical structure. Notably, it has been reported that particulate β-glucans, rather than soluble β-glucans, must be presented as ligands to activate Dectin-1 signaling.

In our laboratory, we confirmed that scleroglucan aqueous solution forms a true gel when left at 4°C for over 20 hours. In this context, a true gel refers to a semi-solid state

containing a large amount of water and exhibiting a distinct fracture surface upon rupture. Achieving this gel state requires partial association between polymers to form a three-dimensional network structure throughout the material. Compared to the gel, the aqueous solution of soluble β-glucan is a liquid state where individual molecules are dispersed in water, while aqueous dispersions of insoluble particulate β-glucan can be regarded as suspensions where particles formed by the aggregation of numerous molecules are dispersed in water. Therefore, the true gel state of scleroglucan is considered to be distinct from both solution state of scleroglucan and the dispersion state of insoluble particulate scleroglucan. This study investigated the effect of the gel state—neither a solution nor an insoluble β-glucan suspension—on the biological activity of scleroglucan.

A 0.6 wt% scleroglucan aqueous solution containing 70% glycerol formed a true gel upon cooling and maintained its gel state even at 40°C. We examined both applying this true gel directly to the culture plate and applying it to the culture plate in a microgel state. Microscopic observation of the microgel revealed rod-shaped gels exhibiting anisotropy. To evaluate the degree of Dectin-1 activation, the amount of TNFα released from macrophage-like cultured cells RAW264 was compared between cases where this microgel was added and cases where scleroglucan and glycerol in solution were added as a control. The amount of TNFα released from cultured cells to which scleroglucan solution was added to the medium was significantly increased compared to when it was not added. At the conference, we will present the effect of true scleroglucan gel on TNFα release compared to scleroglucan solution or suspension.

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[1190] Pickering emulsion stabilized by seaweed cellulose nanofibers

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The escalating global demand for polysaccharides as gelling agents and thickeners, particularly within the food industry, has intensified seaweed cultivation. While a portion of the residual biomass post-polysaccharide extraction is repurposed as animal feed or fertilizer, the majority is discarded as industrial waste. Due to the low lignin content of seaweed compared to woody biomass, it presents a promising feedstock for the efficient recovery of high-purity cellulose. This study investigates the feasibility of utilizing cellulose

nanofibers (CNFs), derived from seaweed residue, as particulate stabilizers for the formulation of oil-in-water (O/W) Pickering emulsions.
The red macroalga *Kappaphycus alvarezii*, cultivated in Indonesia, served as the raw material. Following carrageenan extraction via hot alkaline aqueous treatment, the residual biomass was subjected to drying, mechanical pulverization, oxidative decolorization using hydrogen peroxide, and acid hydrolysis with sulfuric acid. The resulting CNFs were isolated through successive centrifugation and washing steps to achieve neutral pH.
Emulsification was conducted by dispersing CNFs in deionized water, followed by the addition of soybean oil. The mixture underwent high-speed rotor-stator homogenization to form a coarse emulsion, which was subsequently refined using high-pressure homogenization. Optical microscopy and laser diffraction analysis revealed a monomodal droplet size distribution centered around 15 μm, indicating the formation of a relatively uniform emulsion.
Stability assessments over a 7-day period at ambient temperature demonstrated that approximately 90% of oil droplets remained within the 5 - 20 μm range, with minimal coalescence observed. Even after 50 days of static storage, the droplet size distribution remained largely unchanged. This stability could be explained by the formation of Pickering emulsions, wherein CNFs adsorb onto the oil-water interface, thereby inhibiting Ostwald ripening.
In conclusion, the findings substantiate the potential of seaweed-derived CNFs as sustainable, bio-based stabilizers for the preparation of stable O/W emulsions, offering a viable alternative to conventional synthetic emulsifiers in food and related applications.

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[1193] Collagen hydrolysate–based oral films supporting muscle health and mitigating sarcopenic decline

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Muscle health is vital for quality of life in older adults, but those with dysphagia often struggle to consume conventional protein or amino acid supplements. To offer an easier-

to-consume alternative, we developed orally disintegrating films (ODFs) containing collagen hydrolysates (CH) from pollock skin and citrus peel extract. Two variants were prepared with leucine (0.5–1.0%) or β-hydroxy-β-methylbutyrate (HMB, 0.5–2.0%), designated as CH/Leu and CH/HMB. The films displayed uniform structural properties (thickness 0.21–0.27 mm; opacity 0.18–0.27) and rapidly disintegrated in the mouth (CH/Leu: 10–14 s; CH/HMB: 13–18 s). Surface pH values (5.67–6.93) were within physiologically acceptable limits.

Under simulated gastrointestinal conditions, both formulations showed efficient intestinal release, reaching cumulative release rates of 98% (CH/Leu) and 96% (CH/HMB). Release behavior fit well to the Kopcha ($R^2 \geq 0.996$) and Peleg ($R^2 \geq 0.999$) models, indicating a diffusion-dominant mechanism favorable for targeted nutrient delivery.

To further assess the muscle-supporting potential of the developed ingredients, we evaluated the bioactivity of green tangerine–extracted collagen (GEC) in C2C12 myoblasts. In a dexamethasone (DEX)-induced atrophy model, DEX reduced myotube diameter by 36.6%, while leucine or HMB partially restored it. Although GEC alone had minimal effect, co-treatment with GEC (100 μg/mL) and HMB (50 μM) produced a synergistic increase in myotube diameter that surpassed control levels. Immunofluorescence analysis showed that MyHC expression suppressed by DEX was fully restored by the combined treatment.

Western blot analysis supported these findings by showing that DEX downregulated MyHC, mTOR, and p70S6K while increasing MuRF1 and Atrogin-1. HMB partly reversed these changes, whereas GEC alone showed limited activity. In contrast, co-treatment restored anabolic signaling markers and reduced catabolic regulators to control or below-control levels. These results indicate that GEC enhances HMB-mediated protection against muscle atrophy by promoting anabolic pathways and suppressing muscle degradation.

Overall, CH-based ODFs enriched with leucine or HMB demonstrated favorable physicochemical properties, rapid oral disintegration, efficient intestinal release, and synergistic anti-atrophic effects when combined with GEC. These films offer a safe and practical nutritional strategy to support muscle health in older adults with dysphagia. Further studies should address long-term safety, regulatory considerations, and clinical validation, and explore optimized formulations or additional bioactives for personalized muscle health applications.

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[1204] Microalgal Protein–Alginate Cryogels for Enhanced Lyoprotection, Gastrointestinal Stability, and Controlled Release of *Lacticaseibacillus rhamnoses* GG

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Living drug carriers, including probiotics, prebiotics, and engineered microbes, are reshaping the field of therapeutic delivery by providing dynamic, host-responsive platforms with the capacity to address complex gastrointestinal, metabolic, neurological, and immune disorders. Encapsulation has emerged as a powerful approach to improve probiotics stability and performance by providing physical and biochemical barriers against stress factors. Conventional methods, such as spray-drying, extrusion, or emulsification, can improve survival, but often at the expense of reduced cell viability or limited scalability. Unlike bead- or film-forming processes, cryogelation generates interconnected macroporous networks under sub-zero conditions, allowing high cell loading while maintaining metabolic exchange and recovery of viable cells. These features are particularly advantageous for living drug carriers, as they combine effective protection with structural properties that support the long-term persistence and functional activity of encapsulated microbes.
This study investigated the structural, functional, and biological performance of spirulina (SPI), chlorella protein isolate (CPI), and blended SPI:CPI, sodium alginate (NaAlg) cryogels as delivery systems for Lacticaseibacillus rhamnosus GG (LGG). FTIR confirmed characteristic amide and carbohydrate-associated bands, while deconvolution of the amide I region indicated protein aggregation dominated by intermolecular β-sheet structures. Water sorption analysis revealed type III isotherms with high monolayer moisture contents, attributable to the hygroscopic maltodextrin–protein–alginate matrix. Thermogravimetric analysis showed four major mass-loss events corresponding to residual moisture, glycerol decomposition, polysaccharide breakdown, and protein–carbohydrate degradation. Mechanical testing indicated comparable stiffness and hardness across all formulations, suggesting that structural integrity is governed primarily by ice-templated macroporosity. μCT and SEM visualisation confirmed highly porous (76–78%) cryogel networks with protein-dependent differences in pore-wall smoothness, thickness, and collapse behaviour under high humidity. All cryogels disintegrated rapidly upon hydration, consistent with capillary-driven infiltration and erosion. Semi-dynamic gastrointestinal digestion demonstrated distinct colloidal transitions, with SPI forming compact gastric aggregates that improved LGG retention and controlled release in the intestine. Intestinal viability was highest for SPI cryogels, which also preserved adhesive capacity toward intestinal epithelium, indicating maintenance of key surface structures. Weibull modelling of storage data revealed strong effects of water activity and temperature on LGG survival. At aw 0.11 and 20 °C, shelf-lives ranged from 183–320 days, whereas high humidity or elevated temperature drastically accelerated inactivation.

Across conditions, β values >1 indicated convex inactivation curves associated with cumulative cellular damage. Overall, SPI-based cryogels provided the most robust protection during processing, storage, digestion, and epithelial adhesion, highlighting their potential as effective protein-based carriers for controlled probiotic delivery.

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[1205] Viscoelastic characterisation of high protein ice cream: Predicting tactile sensory properties via time–concentration superposition and large amplitude oscillatory shear (LAOS) rheology

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Ice cream is a complex colloidal food matrix composed of different structural elements, i.e., air cells, ice crystals and partially coalesced fat droplets dispersed in a continuous freeze-concentrated aqueous phase. Owing to the ice cream structural complexity, small amplitude oscillatory shear (SAOS) rheology has been successfully applied for the viscoelastic characterisation of ice cream as influenced by the mix composition, freezing process and frozen storage conditions. Large amplitude oscillatory shear (LAOS) rheology is an emerging characterisation method in the domain of food colloids due to its ability to allow “near real measurement” of complex food systems. Hitherto, LAOS has been successfully employed for the assessment of the techno-functional interplay of food ingredients (e.g. proteins, polysaccharides, fats, etc) and understanding the structural complexity of real food matrices such as emulsions, foams and gels. Nonetheless, the interrelationship between LAOS properties and sensory textural aspects involving large deformation without solid-to-molten physical state transitions has not yet been explored. The aim of the present work was to showcase the feasibility of LAOS as an instrumental tool for associating the changes in the structural integrity of ice cream with its major tactile sensory modalities at serving temperature.
Three common tactile sensory properties of ice cream i.e., resistance to scooping (scoopability), creaminess and gumminess were assessed in high protein formulations differing in their protein to fat ratio ($\varphi_{P/F}$ = 0.9 to 4) and protein source (milk protein concentrate (MPC) vs whey protein isolate-sodium caseinate (WPICAS) 1:1 blend). The complex viscosity – angular frequency data obeyed the TCS principle with the calculated shift factors reflecting effectively the compositional profile of ice creams i.e.,

$a_c \propto \varphi_{P/F}^{1.16}$ and $\varphi_{P/F}^{2.23}$, $b_c \propto \varphi_{P/F}^{-1.27}$ and $\varphi_{P/F}^{-1.75}$ for MPC and WPICAS fortified systems. LAOS assessment revealed a clear impact of protein type and $\varphi_{P/F}$ on the shearing deformation of ice creams. MPC fortification and decrease in the $\varphi_{P/F}$ enhanced the shear flowing ability of the ice creams. In all cases, the onset of shear stiffening and thickening behaviour was observed at shear stresses below the flow point, which indicates gel-like or colloid glass-like structures. According to partial least squares regression analysis, the TCS parameters (a_c and b_c), damping factor (tanδ) and the shear strain (γ_f) and elastic modulus (log G'_f) at flow point were determined as the most important parameters predicting tactile sensory modalities on large deformation (spooning) such as scoopability, creaminess and gumminess.

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[1206] ENTANGLE project: Machine learning aided development of industrial galactomannan derivatives from forage legume seeds. A case study on a locust bean gum analogue

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Galactomannans are plant seed-derived polysaccharides widely recognised for their industrial applications. This stems from their inherent techno-functional properties including thickening, gelling, cryogel formation and interface stabilisation. Previous studies have demonstrated that the molecular conformational properties of galactomannans are inextricably associated with their bestowed techno-functionality, with the mannose-to-galactose ratio (M/G) being the most critical parameter. Generally, high galactose substituted galactomannans (M/G ~ 1-2) are well known for their high thickening capacity and cold-water solubility and swelling ability. On the other hand, further increase in the M/G ratio favours the gelling and cryogel forming capacity of galactomannans but compromises their cold-water solvation affinity.
Despite their industrial importance, galactomannans currently face a significant supply-demand gap. This is not only due to the steadily increasing use of galactomannans in industrial commodity applications (food, nutraceuticals, pharmaceuticals, composite materials, etc.) but also to the fact that the yield of galactomannan-producing crops (i.e., fenugreek, guar, tara, carob, and cassia) is being reduced due to climate change and the geographically and ecologically restricted cultivation of these crops. Recently, our team demonstrated that the seeds of forage legume crops such as alfalfa (*Medicago sativa L.)* and clover (*Trifolium pratense L.*) are promising highly sustainable and ecologically

resilient bioresources of industrially relevant galactomannans with an M_w of 1500-2200 kDa and M/G <1.2.
ENTANGLE project aims a machine learning assisted bioprocessing approach for developing galactomannan derivatives of broad techno-functionality including thickening, gelling, texturizing, cryo-structuring and health promoting properties. The present work showcases a bioprocessing-based approach for producing a locust bean gum analogue from alfalfa seeds isolated galactomannans. Compared to the native alfalfa gum (AAG) the modified AAG (mAAG) exerted notably diverse structure conformational properties leading to significantly enhanced thickening and cold-gelling behaviour. mAAG exhibited a mirroring cold-gelling behaviour to purified commercial LBG whilst it outperformed LBG in terms of its cold-gelling and cryogelling synergism with other industrial hydrocolloids such as xanthan gum and kappa-carrageenan.

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[1207] Structure-activity relationship of lichen polysaccharides in immunomodulation and keratinocyte migration

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Bioactive polysaccharides are attractive targets for skin repair and immune modulation, yet lichen-derived polysaccharides remain underexplored. Water-soluble polysaccharides (WSPs) were isolated from *Peltigera praetextata* (PP) and *P. aphthosa* (PA) using the hot-water extraction method and were evaluated for their bioactivities in human health. Composition analysis (HPLC-SEC, FT-IR, and 1D/2D NMR) confirmed that the PP fractions were mannan-rich with a galactomannan-like profile, whereas the PA fractions were enriched in galactose with minor fucose content. PP polysaccharides exhibited significant pro-migratory activity in HaCaT keratinocytes compared with untreated controls. The NaCl-assisted hot-extracted fraction (**2B**) of PP showed dominant activity across assays, accelerating the scratch gap closure and elevating macrophage uptake with minimal cytotoxicity through an autophagy-dependent pathway. Autophagy behaviour

was selectively modulated in RAW264.7 cells but largely unchanged in PC3 cells. Under basal conditions (non-LPS), nitric oxide levels were close to those of untreated controls for most samples. Cytotoxicity was modest overall, with selective cytotoxicity observed in PC3 cells compared with HaCaT keratinocytes. In contrast, galactose-predominant fractions were associated with lower basal nitric oxide output. These findings reveal a structure-activity relationship in which mannose-enriched fractions were associated with pro-migratory keratinocyte responses and enhanced macrophage function, while galactose-rich fractions attenuate inflammatory reactions. This work presents lichen-associated polysaccharides as potential candidates for applications in skin repair and immune modulation.

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[1211] Long-term stability of algal polysaccharides

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Algal polysaccharides are versatile hydrocolloids widely used in both food and non-food applications. Their functional properties, particularly viscosity and gel formation, depend strongly on their molecular weight. While it is well known that isolation and processing can decrease molecular weight and thereby alter viscoelastic behavior, much less is understood about the long-term stability of these polysaccharides during storage as dry powders. Such information is essential for establishing best storage practices and for assessing the reliability of samples used many years after preparation.

In this study, 24 polysaccharide samples were stored as dry powders for 5 and 10 years at room temperature, +4 °C, -20 °C, and -80 °C. Molecular weights were measured by high-performance size-exclusion chromatography, and samples included common algal polysaccharides, such as agarans, carrageenans, and alginates, as well as pullulan, dextran, and pectin for comparison. Comprehensive characterization was performed by NMR spectroscopy, while mineral part composition and sulfate content were quantified by ion chromatography.

Our results show that long-term storage can substantially reduce the molecular weight of polysaccharides, particularly in samples containing low levels of stabilizing metal ions. In some cases, molecular weight decreased by more than 50% over 10 years. Storage at -20 °C significantly limited degradation, whereas samples stored at -80 °C exhibited no measurable decrease in molecular weight even after a decade. For commercial agaroses, the extent of degradation correlated strongly with sulfate content.

These findings highlight the critical importance of low-temperature storage for preserving the molecular integrity of polysaccharides and ensuring long-term sample stability. This

insight is especially valuable for manufacturers and research laboratories, for whom the long-term functional reliability of polysaccharide-based materials is essential.

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[1212] Valorisation of *Podophyllum hexandrum* rhizomes: bioactive polysaccharides from an underutilized biomass

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The roots and rhizome of the medicinal plant *Podophyllum hexandrum* (Himalayan mayapple) are the primary source of podophyllotoxin, a critical reagent for the production of essential anti-cancer medications, etoposide and teniposide. The slow growth and overharvesting of *P. hexandrum* for podophyllotoxins have led to its global endangerment *[1].* After processing for lignans, the remaining biomass still contains undefined and potentially valuable water-soluble compounds.

Anti-inflammatory, antioxidant, and radioprotective properties have been demonstrated in aqueous extracts of *P. hexandrum [2–4]*. Recently, antioxidant and immune-stimulatory properties were attributed to polysaccharides in the fruit of *P. hexandrum* [5], but the polysaccharides present in the rhizome and roots have not been studied. We aimed to valorise this waste product by isolating these polysaccharides, characterising their chemical structure, and evaluating their bioactive properties.

P. hexandrum polysaccharides were extracted under acidic, neutral, and basic pH and at room and elevated temperature conditions, then purified. The molecular weight distributions of isolated polysaccharides were estimated using HPLC-SEC-RI. The structural features were analysed using Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy, and ^{1}H-NMR. Cell assays were used to test for the bioactive properties of the polysaccharides and potential human health benefits were assessed.

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[1213] Sulfation of pectic acids: selectivity and sulfation patterns

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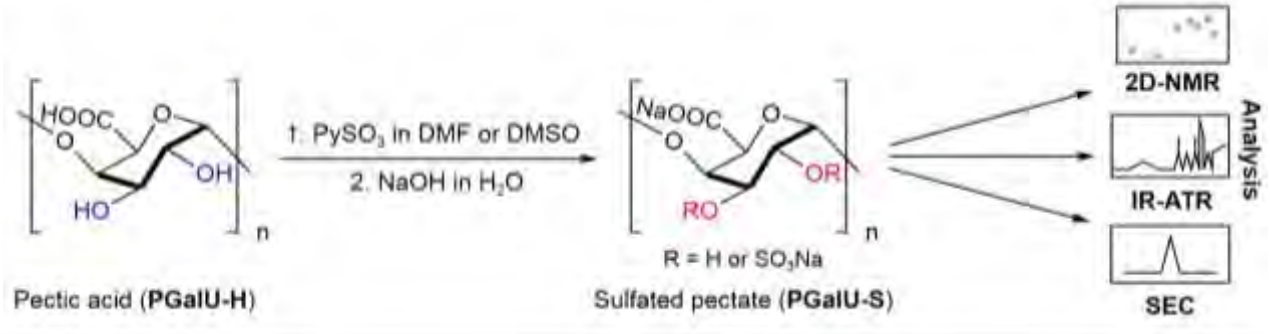
Pectic acids, also known as polygalacturonic acids, are demethylated derivatives of pectins. Sulfated pectins have been found to have anticoagulant[1] and antiviral[2] activity. However, little information exists on sulfation patterns of obtained derivatives, necessitating further study.

In this work, aim was to sulfate and comprehensively characterize the sulfated pectates. To do this, we first sulfated pectic acids in DMF or DMSO with Py·SO_3 in various conditions. Protecting groups, such as benzoyl and TBDMS-group were also used in an effort to obtain regioselectively sulfated pectates, thus further aiding structural characterization. Then pectate sulfates were analysed, primarily with NMR-spectroscopy, but also with IR-spectroscopy, size-exclusion chromatography (SEC) and elemental analysis (EA).

As a result, information on sulfation patterns, including preferential localization of sulfate groups in galacturonic acid residue, was gathered. Such information can be used to rapidly determine sulfation pattern in future works and thus enable easier determination of structure-property relationship for biomedical applications.



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[1214] Food texture evaluation using deep learning and a six-axis sensor equipped tooth-shaped plunger

-Exploring key factors for detailed characterization of food texture-

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About 60% of palatability comes from texture. Sensory evaluation is widely used but depends on subjective factors, while instrumental analysis is objective often disagrees with sensory results. Humans perceive texture through multi-point / multi-directional sensing and texture-dependent mastication, whereas conventional food texture analyzer records only one-axis force during vertical uniform compression independent of each texture. This large gap of experimental conditions is considered a major cause of the discrepancy. Increasing the amount of information obtained during compression and evaluating thousands of measurements could enable more detailed food texture evaluation.

In this study, a machine-learning–based approach was employed to improve the accuracy of texture evaluation to identify key factors contributing to the texture. Two types of automated compression systems were developed. A tooth-shaped plunger and a six-axis force/torque sensor were installed, and compared with the results obtained with conventional simple texture analyzer. Machine learning was applied to the obtained compression results, which is required for more complex results compared with conventional compression instruments. A larger lateral force component was observed with the tooth-shaped plunger than with the conventional disc-shaped plunger. This is likely due to increased lateral sliding during compression of the uneven rice-cracker surface, resulting in larger F_x and M_y values with the tooth-shaped plunger. More than 4,000 compression tests were performed, and two different rice crackers having similar textures were measured. Widely used analysis methods such as TPA (with PCA) could not distinguish the two crackers, whereas the machine learning based method showed higher classification accuracy. Among the six axes, the lateral force component (F_x) and

the rotational moment (M_y) showed improved classification accuracy as the number of measurements increased. These axes reflect lateral movements of the tooth-shaped plunger, suggesting that grinding-type motion plays an important role in texture perception.

The machine-learning–based texture evaluation using a tooth-shaped plunger with a six-axis sensor outperformed conventional methods. The six-axis analysis indicates that grinding-type movements are key factors in detailed texture evaluation.

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[1215] 3D measurements of chewing behavior toward objective evaluation of human sensory test - application of built-in 3D scanner in smartphone -

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Sensory evaluation is essential in food development, and has been widely used to assess the palatability of food. However, simultaneous evaluation of multiple senses (taste, aroma, and texture) and their interactions make it difficult. This method relies heavily on the subject's verbal expression ability, making it difficult to apply to infants. Furthermore, subjective influences limit reproducibility and objectivity.

It is suggested that biological responses could be an effective method to overcome these challenges. It is known that characteristic facial changes occur in response to taste stimuli such as sourness, and that changes in saliva secretion resulting in taste and/or aroma affected food bolus formation. Differences in food bolus formation are also thought to reflect oral movements, i.e., chewing movements, reflecting each food texture.

We developed a smartphone application to measure temporal changes in facial surface shape during mastication. This application uses a smartphone-mounted 3D scanner to capture a 3D coordinate of the face along three axes over time. Using this method, changes in facial surface shape over time were recorded during chewing of food alone and chewing of food containing added sugar, salt, and vanilla flavoring, several hundred times. Deep learning was employed for texture analysis. Deep learning enables automatic extraction of characteristic values even from huge and complex dataset.

The results showed that the presence or absence of flavor could be determined only from chewing behavior with approx.. 70% accuracy for sweetness and 80% accuracy for saltiness and aroma, demonstrating that chewing behavior changes depending on the flavor. Furthermore, when estimating the flavor concentration perceived by subjects while chewing, it was possible to estimate the concentration for taste/flavor from chewing movements alone.

This study revealed that chewing movements change when flavors are added, and that this reflects the flavor intensity perceived by people.

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[1216] Texture control of laser-based food 3D-printed meat analogues by combining muscle fiber-mimetic structures with material control

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Meat analogues have attracted attention due to protein shortages. One of the major challenges in meat analogue development is the reproduction of realistic food texture. Current meat analogues are limited to soft textures similar to hamburger steak and fail to reproduce the characteristic “chewiness” of steak meat. This unique texture is considered to originate from micro to milli-meter-scale muscle fiber structures and the bonding strength between fibers.

In this study, we developed a laser food 3D printer with the potential to mimic muscle fiber structures. Egg white protein combined with a food-grade yellow dye exhibiting an absorption peak at the laser wavelength was used as the printing material. By uniaxial scanning the laser irradiation path, fiber-mimetic meat analogues were produced, and their mechanical properties were evaluated by uniaxial compression tests. This method enabled not only the creation of fiber-like structures but also the control of inter-fiber bonding strength by adjusting laser irradiation positions. By varying the inter-fiber distance, a wide range of textures was achieved, reproducing mechanical properties ranging from easily separable, braised-meat-like textures to steak-like chewiness based on maximum compressive force during fracture tests.

However, sensory evaluation revealed excessively high cuttability and insufficient rubber-like elasticity (springiness). Since texture depends on by both structural design and material properties, material-based modifications were further investigated. Methylcellulose (MC) was incorporated to control texture through changes in crosslinking structures. After laser fabrication followed by cooling and reheating, the printed meat analogue made from MC-containing egg white food ink exhibited more than twice the maximum compressive force compared to that made from egg white alone, along with more gradual post-fracture behavior. Rheological measurements showed an increase in storage modulus (G′) during reheating, indicating reversible reorganization of MC networks.

These results demonstrate that realistic food texture control of meat analogues can be achieved through the combined design of structure and material properties.

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[1217] Physicochemical and Techno-Functional Characterization of Protein Extract from Fermented Soybean by Product (Okara) and Its Application in Mayonnaise

Sri Herliyanti [1],Filia A Meylana[1], Andriati Ningrum[1], Arima Diah Setiowati[1], Manikharda[1], Achmat Sarifudin[2], Rima Kumalasari[2], Riyanti Ekafitri, [2] Dita Kristanti[3], Woro Setiaboma[3], Heli Siti Halimatul Munawaroh[4], Siti Zaharah Sakimin[5], Aunchalee Aussanasuwannakul[6], Lena Breitenmoser[7]

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** *Presenting author : Andriati Ningrum*

Tempeh gembus is a traditional Indonesian fermented food, but it typically has a short shelf life and low economic value. These limitations can be addressed by processing it into flour or hydrolysates, followed by protein extraction to improve its physicochemical and techno-functional properties. Tempeh protein possesses excellent techno-functional traits such as water holding capacity (WHC), oil holding capacity (OHC), and emulsion stability. This study explores the application of protein extract from tempeh gembus flour as an emulsifier in mayonnaise, a semi solid oil in water (O/W) emulsion that relies on emulsifiers for stability. The research aims to evaluate the functional properties of the protein extract, including its suitability as a plant based emulsifier in mayonnaise formulations. The physicochemical (color, protein, fat, moisture, ash, carbohydrates, amino acid composition) and functional (WHC, OHC, emulsifying activity and stability) characteristics of the protein extract were analyzed. Additionally, mayonnaise formulated with varying concentrations of the protein extract was assessed for physicochemical properties, rheological behavior, emulsion stability, and sensory acceptance. Results showed that the protein extract had a lighter color and higher protein, ash, fat, and amino acid content than the flour. It also exhibited superior WHC, OHC, and emulsifying properties. Increasing extract concentration in mayonnaise increased protein and ash content while decreasing fat content, with no significant difference in overall consumer preference compared to the control. This suggests that tempeh gembus protein extract is a promising functional ingredient for more nutritious and stable mayonnaise products.

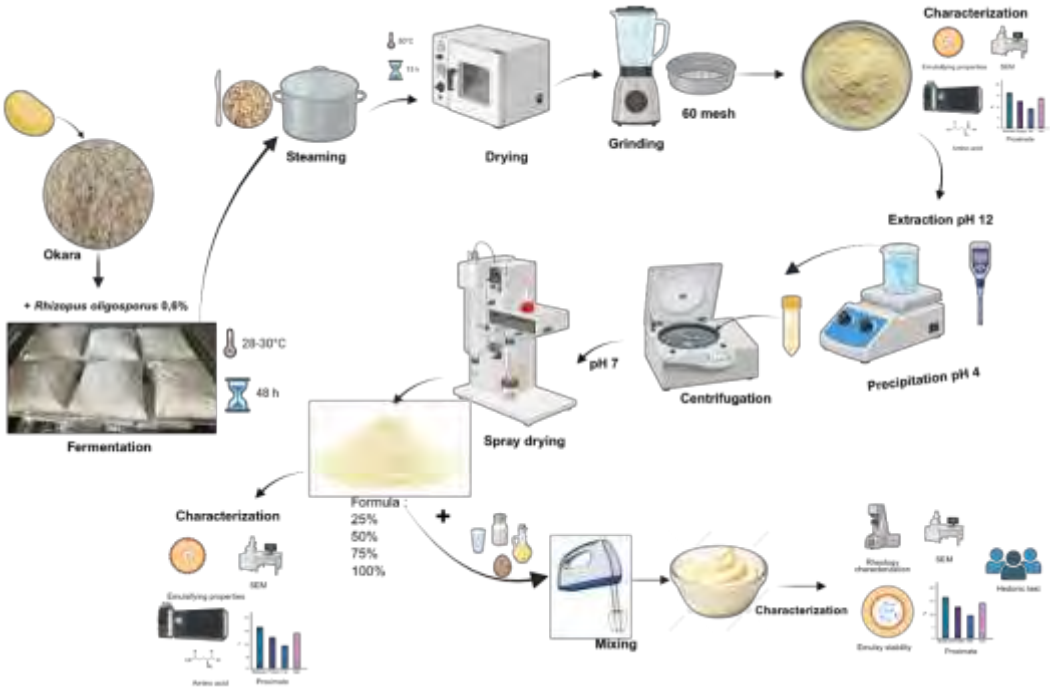

Figure 1. Graphical Abstract

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[1218] Mycelium-based high-fiber bread: the role of *in-situ* produced structurally different dextrans on the texture and digestion properties

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Fungal mycelium is rapidly emerging as a next-generation food ingredient due to its high fiber and protein content, efficient upcycling of agro-industrial waste, and low environmental impact. In this study, we investigated for the first time the role of *in-situ* produced dextran in modulating the texture and digestibility of high-fiber bread formulated from a 50:50 blend of *Cordyceps sinensis* mycelium and wheat flour. We compared two structurally distinct dextrans, high molecular weight and linear structure from *Weissella confusa* VIII40, and lower molecular weight and highly branched structure from *Pediococcus beninensis* DSM 22752. Our findings demonstrate that fermentation with *W. confusa* VIII40 yielded 4.9% (dw) dextran, which significantly improved loaf specific volume, reduced crumb hardness, and delayed staling compared to control, effects not observed with dextran (2.22% dw) from *P. beninensis* DSM 22752 . *In-situ* produced dextran from *W. confusa* VIII40 significantly enhanced the bread's nutritional profile, increasing DPPH radical scavenging activity and bile acid binding activity, while lowering the starch hydrolysis index (HI) and estimated glycemic index (eGI). These effects were linked to partial fiber solubilization and increases in digesta viscosity (2.6-fold) and particle size (1.6-fold) during intestinal digestion.

Overall, integrating *C. sinensis* mycelium with *in-situ* dextran production via fermentation presents a promising strategy for developing clean-label, high-fiber functional breads with improved texture and health-promoting properties.

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1221 Physical property development in starch gelatinization probed by Rheo-SALS and Rheo-Impedance

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Objective
The physical properties of food hydrocolloids are critical for determining texture and quality in food products. In starch-based systems, gelatinization governs the emergence of mechanical rigidity during heating; however, the relationship between microscopic structural changes and macroscopic physical properties remains unclear. In particular, it is still debated which events directly control the onset of rapid mechanical property development relevant to formulation and processing. This study aims to clarify the mechanism of starch gelatinization by identifying how morphological and electrochemical changes precede and converge to trigger macroscopic mechanical transitions, using simultaneous real-time measurements under identical thermal conditions.

Methods
A 10 wt% aqueous wheat starch paste was heated under controlled conditions while its physical properties were monitored using simultaneous rheological, optical, and electrochemical measurements. Rheology was used to track the evolution of elastic moduli (G', G"), morphological changes of starch granules were observed by Rheo-small angle light scattering (Rheo-SALS), and electrical impedance was measured by Rheo-Impedance. The impedance spectra were analyzed using a simplified Hayden model to evaluate changes in the continuous phase and granule interiors associated with amylose dissolution.

Results
G' and G" of the starch paste remained low at lower temperatures and sharply increased at approximately 65 °C, indicating the onset of macroscopic gelation. In contrast, microscopic and electrochemical changes occurred at lower temperatures. Rheo-SALS measurements showed that the characteristic Maltese cross scattering pattern, originating from the concentric layered crystalline structure of starch granules, weakened between 55

and 60 °C, accompanied by rapid granule swelling. Rheo-Impedance analysis revealed significant decreases in both the resistance of the continuous phase R_1 and the internal resistance R_2 of starch granules in the same temperature range, reflecting the release of amylose and electrolytes into the continuous phase.
Importantly, these morphological changes and the onset of amylose dissolution did not result in an immediate increase in elastic moduli. The macroscopic gelation temperature was clearly higher than the temperature at which granule swelling and amylose release began. The sharp rise in elastic moduli was observed only when the morphological and electrochemical changes converged, demonstrating that initial amylose release is insufficient to induce gelation. These results indicate that the temperature associated with morphological changes and amylose dissolution is distinct from that of macroscopic gelation.

Conclusion

Starch gelatinization does not occur instantaneously upon granule morphological changes or amylose release into the continuous phase. Instead, macroscopic gelation emerges only after the concentration of dissolved amylose exceeds a critical threshold required for a percolation transition. Thus, morphological transformation and amylose release are necessary but not sufficient conditions for gel formation. This clear separation between microscopic transformation temperature and macroscopic gelation temperature provides a mechanistic framework for understanding physical property development in starch-based food systems and offers practical guidance for controlling texture through formulation and thermal processing.

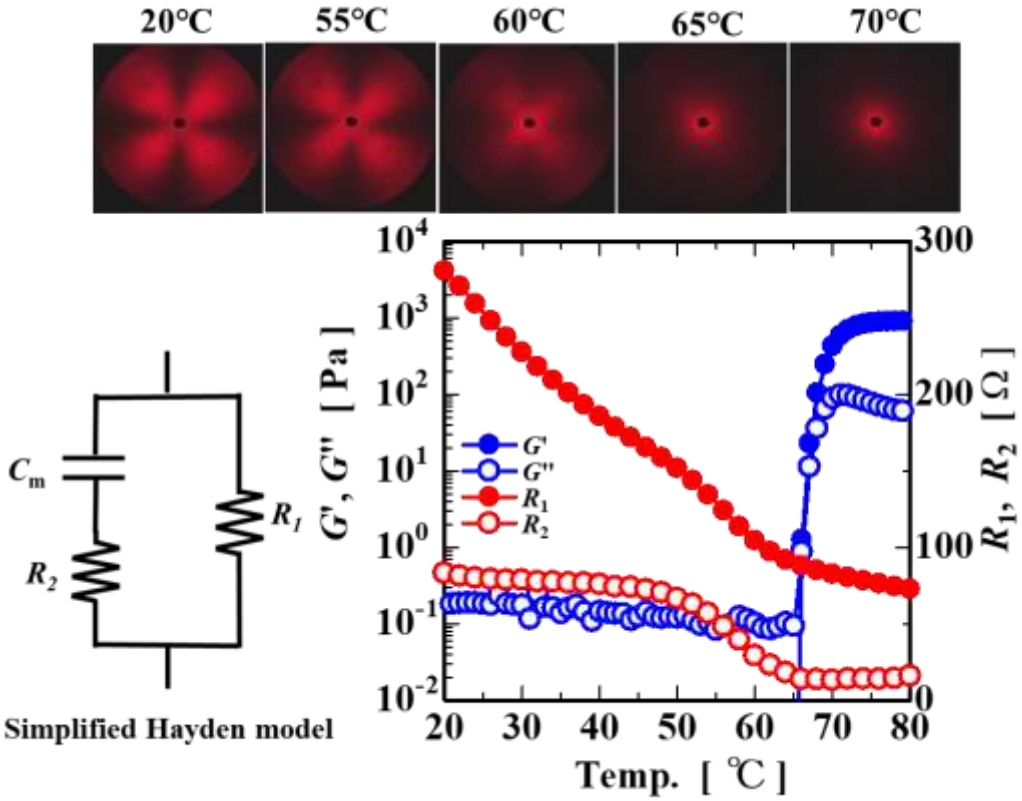

Figure 1. Hayden model representation of a starch paste and simultaneous changes in rheological properties, SALS patterns, and electrochemical characteristics during the gelatinization process.

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1222 Effects of Water-Addition Level and Pre-Gelatinized Starch (Rice Porridge) on the Retrogradation and Nanoscale Structural Development of Rice Gels

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Starch-based foods often undergo quality deterioration during low-temperature storage due to starch retrogradation, and the incorporation of pre-gelatinized starch has been proposed as a strategy to mitigate this problem[1)]. Rice porridge can be regarded as a form of pre-gelatinized starch, and previous studies have shown that its addition accelerates

recrystallization under low water-addition levels but suppresses it under high water-addition levels. These contrasting effects suggest that the hydration environment plays a decisive role in determining how pre-gelatinized starch influences retrogradation, yet the underlying structural mechanisms remain unclear.
This study aimed to clarify how different water-addition levels affect the gelatinization and retrogradation behavior of rice flour gels, and to elucidate how the composition of the pre-gelatinized starch contributes to nanoscale structural changes during heating and storage. Rice flour gels were prepared by mixing rice flour with 1–2× water and replacing 0–20% of the flour with porridge made from non-glutinous rice. The suspensions were gelatinized at 100 °C for 30 min, stored at 15 °C for up to 4 days, and analyzed by X-ray diffraction to determine recrystallization. Time-resolved SAXS measurements were conducted during heating from 30 to 95 °C to evaluate changes in lamellar structure, and scattering profiles were analyzed to obtain the long period and the thicknesses of amorphous and crystalline layers.
Recrystallization increased with the addition of porridge under 1–1.25× water but was suppressed under 1.75–2× water, with 1.5× water showing transitional behavior depending on the amount added. SAXS analysis revealed that porridge had little influence on nanoscale structure during gelatinization at 1× water, whereas at 2× water it increased the lamellar long period by altering the balance between amorphous and crystalline layer thicknesses. These findings demonstrate that the effect of pre-gelatinized starch on starch retrogradation and nanoscale structural development is governed primarily by the water-addition level, and that pre-gelatinized starch can either promote or suppress retrogradation depending on the hydration conditions during preparation.

1) Y. Dang et al, *Food Hydrocolloids*, 109159, (2023).

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1223 Reversible and irreversible changes in protein secondary structure in the heat- and shear-induced texturization of native pea protein isolate

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The molecular mechanism of plant protein texturization under extrusion conditions was unraveled at the secondary structure level by decoupling the effects of heating, cooling and shearing on protein secondary structure. Native pea protein isolate hydrated at 50 % w/w in H_2O and in D_2O, to allow detailed resolution of protein secondary structure, was subjected to temperature cycling in a temperature-controlled ATR-FTIR and was

texturized at the gram scale by microcompounding. Upon heating without shearing, native α-helices and intramolecular-β-sheets unfold to random domains, followed by the formation of intermolecular β-sheets, inducing aggregation. During cooling, the intermolecular β-sheets become increasingly ordered, and random domains partially fold into non-native β-structures. Combined heating and shearing results in more extensive β-sheets than heating alone. The resulting β-rich structures provide for an entangled network of protein chains and a cohesive protein matrix. The effect of shear on protein association/dissociation is controlled by the specific mechanical energy (SME), with the degree of intermolecular β-sheet formation increasing with increasing SME values up to ~1000 kJ/kg, followed by a gradual decrease with further increases of the SME. The detailed molecular insights in the mechanism of plant protein texturization allows for a more controlled design of novel food products, including matrices for use in meat analogues.

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1224 Exogenous α-glucosidase enzyme alters the histological structure and retrogradation inhibition of cooked rice grains

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Endogenous and added enzymes influence the sensory properties of cooked rice by acting on starch during gelatinization. This study elucidated the distinct spatial distributions and structural effects of endogenous α-glucosidase (E-AG) and exogenous α-glucosidase derived from *Aspergillus niger* (A-AG) during cooking. As shown in Fig.

1(a), E-AG was distributed throughout the raw grain after soaking for 1 h in an aqueous A-AG solution, whereas A-AG penetrated the grain and localized along the cell walls. With A-AG, the cooking time was prolonged by approximately 1 min, and the temperature rise from 85 to 100 °C became more gradual. This phenomenon is attributed to increased endothermic reactions caused by the enhanced starch hydrolysis and gelatinization that occur in enzyme-added rice. A-AG acts not only on the surface layer but also on the inside of the rice grains and contributes to the suppression of starch retrogradation, as shown in Fig. 1(b). Our research indicates that A-AG's preservation effect is related to its localization.

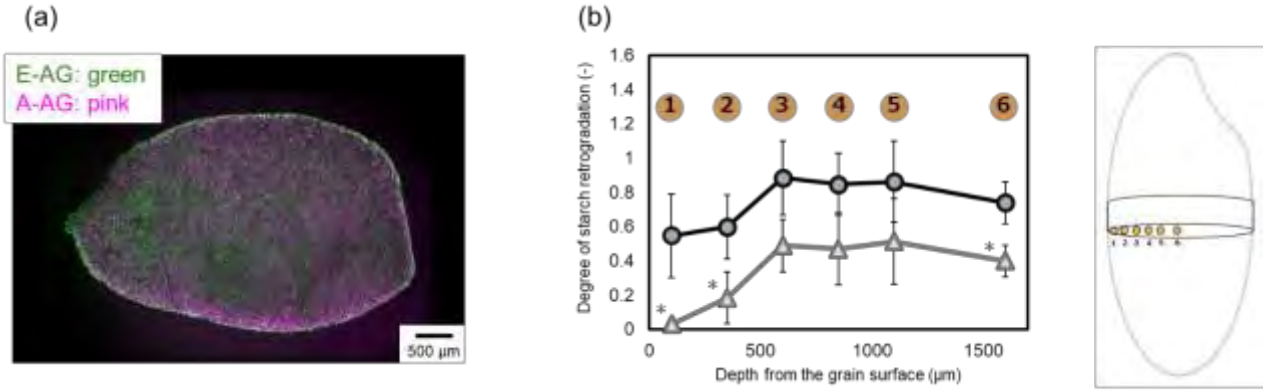

Fig. 1 (a) Double fluorescent immunostaining images of rice grains soaked for 1 h in an A-AG solution. E-AG: green, A-AG: pink (penetrating the grain). (b) Intragranular distribution of the starch retrogradation degree in cooked rice grains, measured by X-rays at 6 sites after being stored for 2 days at 15 °C. Control (○) and A-AG-treated (Δ) samples. Retrogradation was suppressed at all measurement sites by A-AG addition (n=3, *p<0.05).

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[1018] Effects of xyloglucan on metabolism in humans (preliminary study)

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【Objective】 After Fukushima disaster in 2011, radioiodine fallout could be largely incorporated and fixed in the xyloglucan of cell walls in Fukushima forest trees. Since xyloglucan has been used for the food glycan, we attempted to use xyloglucan instead of

the stable iodine tablets for human bodies against radioiodine. At first, we examined the levels of non-digested xyloglucan through human bodies and also the effects of xyloglucan on the bodies.

【Method】 Three healthy subjects were given 10g x 7days of xyloglucan, and their excretion in the stool was examined. Ten healthy subjects their 20s who were subjected to a normal initial triglyceride level range of 60-150 mg/dl were selected and subjected to 10 g of xyloglucan per day for 7 days to examine changes in blood parameters between before and after intake of xyloglucan was determined by t-test.

【Result】 In three healthy subjects of xyloglucan was metabolized and remained 4.1% in the stool. The change in mean stool volume due to xyloglucan ingestion increased from 128 g/day before ingestion to 161 g/day after ingestion period.

In ten healthy subjects xyloglucan ingestion significantly reduced significantly ($p<0.05$) both blood cholesterol levels from 175.4 mg/dl to 166.7 mg/dl and triglycerides from 98.8 mg/dl to 73.4 mg/dl, respectively.

This is the first report on the effect of improving lipid metabolism in continuous intake of xyloglucan in humans. In this study, the presence of xyloglucan in feces was small, suggesting the effect of assimilation by intestinal bacteria and the effect of short chain fatty acids, which are assimilation products, on lipid metabolism.

1)Nonaka, M. et.al Forests, 11, 957,1-10(2020); doi:10.3390/f11090957

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[1020] Effects of Spray-Drying Carrier on Physical Properties of Mucilage Powder Extracted from Lemon Basil Seed Using Ultrasonic-Assisted Extraction

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The mucilage from lemon basil (*Ocimum* × *africanum* Lour) seeds serves as an excellent food hydrocolloid and can be extracted using ultrasonic-assisted extraction (UAE). Previously, the seeds were soaked in deionized water at a solid-to-liquid ratio of 1:40 (w/w) before applying UAE. The extract contained only 0.6 g of solid per 100 g of solution. Despite its high viscosity of 70 mPa·s, the mucilage was successfully turned into a powder, with a moisture content below 2% (w/w) through spray drying. Maltodextrin at

15% (w/w) was added as a carrier during spray drying to improve solid recovery. However, the initial results showed no significant improvement in solid recovery; the physical properties of the extract needed clarification. In the preliminary study, the SEM micrographs revealed that the addition of maltodextrin altered the shape and increased the particle size of the powder.
To estimate the effect of maltodextrin, other physical properties, such as water and oil absorption capacity, emulsification stability, and dispersion stability, of the spray-dried powder were also measured. Furthermore, the rheology of the extracted and rehydrated mucilage was examined in this work.

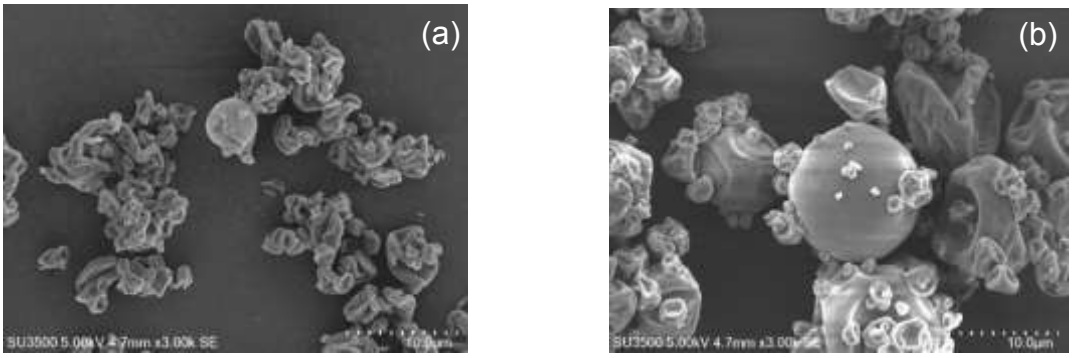

Fig 1. SEM micrographs of (a) mucilage powder spray dried without maltodextrin and (b) mucilage powder spray dried with maltodextrin

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[1043] Fermented Pea Protein as a Functional Ingredient in Plant-Based Drink

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Abstract
Dairy-free milk alternatives have become one of the most dynamic segments in the plant-based beverage sector and is largely driven by shifting consumer dietary habits, including a greater emphasis on plant-forward diets. Pea protein due to its favorable amino acid composition, high digestibility, and comparatively low environmental footprint was the plant-based protein studied. However, its poor solubility adversely affects not only protein functionality but also the texture, stability, and overall sensory quality of finished products. A further barrier to consumer acceptance is the presence of characteristic “beany” or “grassy” off-notes, which can dominate flavor profiles and limit market success.
Fermentation techniques were used to address these functional and sensory limitations. More specifically, Shiitake mushroom (*Lentinus edodes*) mycelium fermentation with pea protein was studied to delivered both nutritional benefits and unique flavor compounds.
This study investigates the impact of shiitake mushroom mycelium fermentation on the physicochemical, functional, nutritional, and sensory characteristics of pea protein. Key parameters examined include changes in protein and ash content, protein solubility, and water- and oil-holding capacities. *In vitro* protein digestibility of non -fermented and fermented pea protein was measured using two methods-the pH drop method and a 2step procedure using pepsin and pancreatin.
Functional properties were evaluated through foaming capacity and foam stability measurements, while amino acid profiling and Size Exclusion Chromatography was performed to assess protein depolymerization and nutritional quality. Sensory analysis focused on the reduction of characteristic off-flavors and improvement in overall flavor acceptability. Chromatograms from the UV detector for control and fermented pea proteins showed no change in protein retention time, indicating fermentation did not depolymerize proteins
The fermented proteins were then incorporated into model plant-based beverage systems to evaluate microstructural stability using microscopy and light scattering techniques, and their composition and sensory performance were benchmarked against commercial plant-based protein beverages. Non-fermented and fermented pea protein, the drinks made from each and the commercially available pea protein drinks were analysed for the flavour compounds guanosine-5' monophosphate (GMP), uridine-5' monophosphate (UMP), inosine-5' monophosphate (IMP), adenosine -5' monophosphate (AMP), monosodium glutamate (MSG)
Collectively, these findings provide insights into the potential of shiitake fermentation as a strategy to enhance the technological functionality, sensory appeal, and market competitiveness of pea protein–based dairy-free beverages.

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[1061] Effects of tamarind seed gum in frozen desserts: ice crystal stabilization and shape retention

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INTRODUCTION

The key effects of polysaccharides in frozen desserts are “ice crystal stabilization” and “shape retention”. In this study, these two effects of tamarind seed gum (TSG), a polysaccharide first industrialized in Japan, were investigated by comparing it with locust bean gum (LBG) and guar gum (GG). In particular, the effect of TSG on the stabilization function of ice crystals was quantitatively clarified.

METHODS

Frozen desserts were prepared using standard formulations containing polysaccharides: TSG (0.30 wt%), LBG (0.30 wt%), GG (0.30 wt%), and a combination of TSG (0.15 wt%) + LBG (0.15 wt%). To evaluate the shape retention effect, the weight of melted product was measured after leaving the samples at room temperature.

The morphology of ice crystals was evaluated using the analysis of curvature distribution, following the method proposed by Matsukawa et al. (2024). In this approach, a series of three consecutive points on the ice crystal surface is selected at regular intervals, and the curvature at the central point is calculated based on the radius of a circle passing through the three points. Then, a curvature distribution is plotted using the calculated curvature values.

The samples composed of 60 wt% sucrose and polysaccharide aqueous solutions were frozen and stored at −28°C for either 3 or 14 days prior to evaluation.

RESULTS

The weight of melt loss after leaving frozen desserts containing each polysaccharide at room temperature for 60 minutes was measured in the following increasing order: TSG+LBG < LBG < TSG < GG. The loss weight of TSG+LBG sample was less than 10%, while that of other samples were exceeded 80%. It was confirmed that the combined use of both TSG and LBG dramatically improved the shape retention of frozen desserts.

The ice crystal morphology was also analyzed. The curvature distributions of ice crystals for samples are shown in Fig. 1. For all samples, the curvature distribution changed from 3 days to 14 days of storage: peaks in the high-curvature range (reflecting round shapes) decreased, while peaks in the low-curvature range (reflecting flat shapes) increased. This reflects the visual change in ice crystal images which shows the amount of large and flat-faced ice crystals was increasing over the frozen storage period. After 3 days of storage, differences between the added polysaccharide types were not significant. However, after 14 days of storage, differences among each polysaccharide became apparent. Compared to LBG and GG, TSG exhibited a larger peak in the range of high curvature and a smaller peak in the range of low curvature. It indicated that the addition of TSG restrained the flattening of ice crystals. Furthermore, when TSG and LBG were combined, the

restraining effect was stronger than TSG. This suggests that the addition of TSG, particularly the addition of combined TSG and LBG, suppressed changes in ice crystal shape during the frozen storage period, thereby stabilizing the ice crystals.

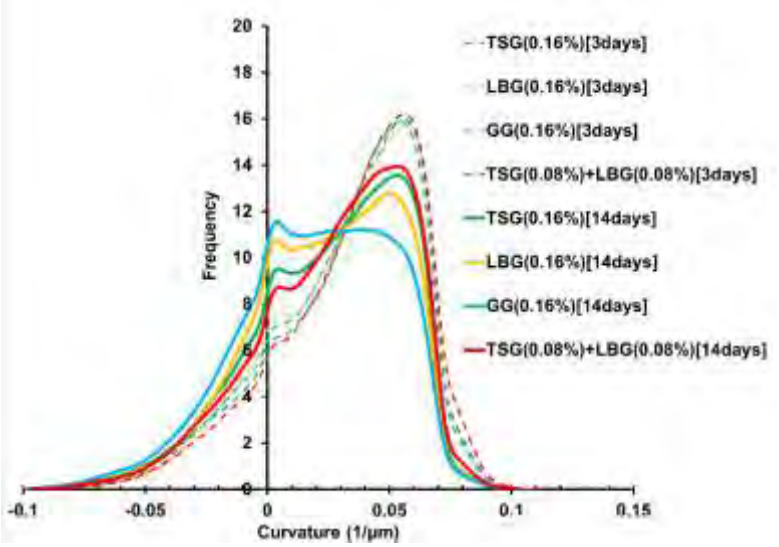

Fig. 1 Curvature distributions of ice crystals in 60% sucrose solution containing different polysaccharides after frozen storage for 3 and 14 days.

Acknowledgements. Authors wish to thank Professor Matsukawa of Tokyo University of Marine Science and Technology for his valuable guidance.

Reference

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1064 Functional potential of protein isolates from narrow-leafed lupin (*Lupinus angustifolius*) versus soy (*Glycine max*) for food innovation

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Soy (*Glycine max*) has long been the most widely used plant-based protein source, widely adopted as an alternative to animal-derived foods. However, as global demand for plant proteins continues to rise, reliance on a single legume crop, such as soy, causes sustainability and supply challenges. Consequently, research attention has shifted towards identifying alternative, underutilised legumes with favourable nutritional and environmental benefits for human consumption. *Lupinus angustifolius* L. (Australian sweet lupin or narrow-leafed lupin) has emerged as a promising crop due to its high protein and dietary fibre content, absence of trypsin inhibitors, and non-GMO status, compared to soybeans. From an environmental viewpoint, lupins are well-adapted to acidic and sandy soils, requiring minimal fertiliser input, and offer a resilient and sustainable option for cultivation in resource-limited agricultural systems. Protein isolates were extracted from dehulled seed flour of five *L. angustifolius* genotypes grown at an experimental site in Merredin, Western Australia, using alkaline extraction and isoelectric precipitation. The resulting isolates were subjected to a comparative evaluation of their thermal, structural, and rheological characteristics, with commercial soy protein isolate (SPI) serving as a reference material. Statistical analysis was conducted using IBM SPSS Statistics (Version 30, 2024). One-way analysis of variance (ANOVA) with Tukey's HSD post hoc test was performed to determine significant differences between groups at $p \leq 0.05$. The DSC thermograms, FTIR spectra, and rheological curves were processed using TRIOS (v5.3, 2023), OPUS (v7.0, 2019) and RheoCompass™ (v1.32, 2023) software, respectively. Fourier Transform Infrared (FTIR) analysis indicated that β-sheets were the most abundant secondary protein structure in lupin protein isolates (LPI), followed by α-helices, with a comparable pattern observed in SPI. Differential Scanning Calorimetry (DSC) revealed two distinct denaturation transitions in the LPI, with peak denaturation temperatures (Td) observed between 84-86°C and 96-98°C, corresponding to the thermal unfolding of the β-conglutin and α-conglutin fractions, respectively. In contrast, the first two thermal transition peaks, corresponding to β-conglycinin and glycinin, respectively, were absent in the soy protein isolate, possibly due to protein denaturation caused by the extraction and post-extraction conditions or the high temperatures employed during spray or drum drying in the commercial production of soy protein isolate. The protein network of LPI lacked a well-defined structure and exhibited a slightly porous, irregular morphology. The microstructure of lupin proteins was less interconnected than soy, which had a more

compact and continuous protein network. Rheological analysis showed that LPI formed weaker and more easily deformable gels, as evidenced by their lower complex viscosity (η*), storage modulus (G′), and loss modulus (G″), along with a higher loss factor (tan δ) relative to SPI. Despite forming comparatively weaker gels than soy proteins, lupin proteins demonstrated higher denaturation temperatures and greater thermal resilience, indicating their potential suitability for incorporation into thermally processed, high-protein food systems. Overall, these findings highlight both the challenges and opportunities of using lupin protein isolates in plant-based products, emphasising the need for targeted process modifications to improve gelation and exploit the thermal resilience of *L. angustifolius* for future food innovations.

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[1065] The rheological properties of the concentrated solid-liquid dispersion systems

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When solid food enters the oral cavity, it is masticated, crushed, and mixed with saliva to form a food bolus, which can be regarded as a concentrated solid-liquid dispersion system. In this study, we examined the physical properties of such concentrated solid-liquid dispersion systems and investigated parameters related to masticatory characteristics from the perspective of food science.

Gelatin was selected as the solid-phase material. The solid-phase material was molded into cubes with sides of 10 mm and subjected to compression tests using a creep meter RE2-3305s (Yamaden Co., Ltd.) at a compression speed of 1 mm/s. The Young's modulus, rupture stress, rupture strain, and rupture energy were determined from the resulting stress–strain curves. To prepare the concentrated solid-liquid dispersion samples, the solid-phase materials were crushed using a sieve (6.7 mm mesh, Tokyo Screen Co., Ltd.) and mixed with pure water. The loss modulus (*G″*) of the prepared concentrated solid-liquid dispersion samples was measured at 25 ℃ using a Rheolographsol (, Toyo Seiki Co., Ltd.) under the conditions of ±50 μm amplitude and 3

Hz frequency. In addition, the particle size distribution of the crushed material was measured from micrographs.

The G'' of the concentrated solid-liquid dispersion samples followed a power-law relationship expressed as $G'' = Ks \cdot W^m$. Where Ks is the proportionality coefficient, W is the solid weight fraction, and m is the nonlinearity index. Here, Ks represents an index of bolus fluidity, while m serves an index of salivary disintegration. A value of m greater than 1 indicates a high degree of salivary disintegration. Furthermore, the energy required to increase the surface area of fragmented material was evaluated by dividing the work necessary for fragmentation by the corresponding increase in specific surface area (ΔS). This value was regarded as an index of masticatory disintegrability. Assuming that the work required for fragmentation is proportional to the rupture energy (E), the ratio $E/\Delta S$ was defined as the apparent rupture surface energy. The results suggest that the apparent rupture surface energy and the nonlinearity index m can be effectively used as indicators for classifying and evaluating the masticatory characteristics of foods.

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[1074] Enhancement of the solubility of poorly soluble compounds by low-molecular-weight tamarind seed polysaccharide

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Introduction. Many functional food ingredients, such as polyphenols and fat-soluble vitamins, exhibit poor water solubility, which limits their absorption, stability, and application in easily consumed functional foods such as beverages. Curcumin is a representative example of a poorly soluble bioactive compound. Tamarind seed polysaccharide (TSP), a natural thickening polysaccharide derived from the seeds of *Tamarindus indica* L., is widely used in food and cosmetic formulations. Previous studies have reported that hydrolyzed TSP with a lower molecular weight can enhance the water solubility of curcumin. Building upon this finding, we investigated whether low-molecular-weight TSP (LMW-TSP) could improve the solubility and emulsifying ability of other poorly soluble substances.

Method. LMW-TSP was prepared through a controllable depolymerization process that is easier to regulate than conventional enzymatic hydrolysis. The solubilizing and emulsifying abilities of the resulting LMW-TSP samples were compared with those of native TSP by measuring the absorbance at 440 nm and 300 nm, using curcumin and fat-soluble vitamins as model compounds. Their physicochemical properties were also evaluated by viscosity measurements using a rheometer. Furthermore, their stability was

assessed by measuring the absorbance of dispersions of curcumin or fat-soluble vitamins stored for a certain period at a specific temperature.
Results. We identified a distinct molecular-weight range of LMW-TSP that effectively enhanced the solubility of curcumin, differing from previously reported ranges. Furthermore, LMW-TSP exhibited a unique emulsifying effect on fat-soluble vitamins, particularly vitamin E. These results suggest that LMW-TSP may facilitate nutrient dispersion and absorption, contributing to the development of novel functional food ingredients.

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1098 Starch–lipid complexation induced by mayonnaise addition enhances RS5 formation and modulates digestion behavior in cold-stored mashed potatoes

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Abstract
Background & Objective: The modulation of starch digestibility through hydrocolloid interactions has garnered significant attention in the design of functional low-glycemic foods. However, the mechanistic role of common food emulsions, particularly mayonnaise, in promoting resistant starch formation during cold storage remains underexplored. This study aimed to elucidate how mayonnaise-induced starch–lipid complexation influences the crystalline structure, enzymatic digestibility, and glycemic potential of cold-stored mashed potatoes, with a focus on RS5-type resistant starch development.

Methods: A model food system was constructed using mashed potatoes with or without mayonnaise (105g potato:24g mayonnaise), subjected to cold storage at 0°C and 10°C for 0–72 hours to simulate commercial cold-chain conditions. Texture Profile Analysis (TPA) assessed product quality, while structural changes were characterized using X-ray diffraction (XRD), differential scanning calorimetry (DSC), and Fourier-transform infrared

spectroscopy (FTIR). Starch digestibility and estimated glycemic index (eGI) were determined via the standardized INFOGEST 2.0 in vitro digestion model, with correction based on total starch content.

Results: The results revealed that mayonnaise addition significantly preserved textural integrity and promoted the formation of B+V-type crystalline patterns, indicating the presence of amylose–lipid V-complexes (RS5). FTIR spectra confirmed the interaction between amylose and unsaturated fatty acids, while DSC thermograms exhibited distinct phase transitions corresponding to RS5 formation, differentiating it from retrograded RS3. In vitro digestion data demonstrated that mayonnaise-containing samples exhibited a 15–28% reduction in eGI and a marked increase in resistant starch fractions, particularly after 72h at 0°C. Compared to control samples, these structural transformations correlated with lower enzymatic accessibility and improved nutritional properties.

Conclusion & Innovation: This study provides the first comprehensive mechanistic insight into how mayonnaise—beyond its deliciousness—can actively induce RS5 formation through starch–lipid complexation during cold storage. The findings establish a novel application of food-grade emulsions in modulating the digestion behavior of starch biopolymers and support a practical strategy for low-GI food formulation. The implications extend to both scientific understanding and commercial development of functional starchy foods with improved glycemic performance.

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[1106] Preparation and Evaluation of a Polyphenol-Containing Tamarind Preparation for the Treatment of Oral Mucositis

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[Objective]

Oral mucositis is a factor that diminishes patients' quality of life (QOL). However, current treatments for oral mucositis face challenges, including poor retention of active ingredients and discomfort during intraoral application. Various water-soluble polymers are used in formulations applied to the oral cavity. Additionally, plant-derived components with antimicrobial activity are gaining attention as potential ingredients to prevent the onset and promote healing of oral mucositis. Therefore, this study focused on xyloglucan (Xylo), which gels upon the addition of polyols. Hydrogels and xyloglucan films were prepared by mixing Xylo with epigallocatechin gallate (EGCG), which has antioxidant and antibacterial properties, and their physicochemical properties were evaluated.

[Methods]

Hydrogels were prepared by mixing a Xylo solution (1.5 w/w%) with EGCG solutions at various concentrations (0.1, 0.25, 0.5, 0.75, 1.0, and 2.0 w/w%), then dispensing the mixture and storing it at 4°C for 24 hours. The hydrogels were then left to stand for an additional 5 days, dried, and formed xerogel films. The tensile strength of the hydrogels, along with the adhesion and water absorption of the xerogels, were evaluated. Additionally, ascorbic acid was added to enhance stability, and the results were analyzed.

[Results and Discussion]

As the EGCG content increased, gel transparency decreased. In the tensile strength test, the hydrogel with 2.0% EGCG showed the highest strength and elongation at break. Regarding adhesion, it measured 1.8 N for 0.25% EGCG and 2.0 N for 2.0% EGCG. Although no significant difference was observed with different EGCG concentrations, the adhesion was similar to that of existing formulations. In the water absorption test, the 0.1% EGCG Xylo gel demonstrated a high water absorption rate. These results indicate that adjusting the EGCG content enables control over the film's strength, flexibility, and water absorption. Therefore, EGCG-containing Xylo gel is suitable for use in film formulations designed for treating oral mucositis.

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[1118] Effect of Thermoresponsive Xyloglucan on the Retrogradation of Gluten-Free Rice Flour Bread

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Introduction: The bread-making properties of 100% rice flour, used to prepare gluten-free bread, is poor. Heat-responsive xyloglucan (MTG), which exhibits gel-forming properties upon heating, is expected to enhance bread-making properties; however, there are no reports on its use in rice flour bread. Therefore, this study investigated the effects of adding various thickening polysaccharides, including MTG, on the dough properties,

bread-making properties, staling characteristics, and sensory acceptability of gluten-free rice flour bread.

Methods: Rice flour bread was prepared by adding MTG, tamarind gum (TG), and xanthan gum (XT) at a 1.0% ratio to rice flour, along with additional ingredients including dry yeast, granulated sugar, salt, and olive oil. It was then baked in a 200°C oven for 14 minutes. Rice flour steamed bread was prepared by substituting baking powder with dry yeast in the rice flour bread ingredients and microwaving at 600 W for 7 minutes. These breads were stored for 48 hours at 25°C and 65% relative humidity to examine the changes in physical properties and staling characteristics arising from storage. Sensory evaluation was also conducted to assess acceptability.

Results: The flow characteristics of the rice flour dough showed dilatancy similar to the control and MTG-added samples, indicating that the dough reflected the properties of starch. The specific volume of rice flour bread was significantly lower in the MTG-added sample; however, for steamed rice flour bread, the MTG-added sample was equivalent to the XT-added sample and was larger than that of the control. The apparent elastic modulus and stress at 40% compression of rice flour bread and steamed bread samples containing thickened polysaccharides were lower than those of the control after 3 days of storage. In rice flour bread, the addition of MTG and TG suppressed the hardening effect. Evaluation of the retrogradation of rice flour bread using X-ray diffraction revealed that the relative strength of the control sample was highest on the 3rd day of storage, whereas the MTG-added sample showed the lowest relative strength. In steamed bread, the addition of thickening polysaccharides suppressed retrogradation; however, no difference was observed between the types of thickening polysaccharides used. In the sensory evaluation, MTG-added rice flour bread and steamed bread were rated as softer than the control, even after 2 days of storage. The MTG-added steamed bread was rated as the softest compared to all other samples. These results demonstrate that adding MTG to rice flour bread suppresses bread hardening and retrogradation and enables the preparation of gluten-free rice flour products with excellent baking characteristics and high palatability, particularly when steamed.

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[1134] Hydrolysis-driven restructuring of mealworm protein hydrolysates and their interfacial functionality in emulsion systems.

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INTRODUCTION

Insect proteins have emerged as sustainable functional ingredients, yet native mealworm proteins often exhibit low solubility and limited interfacial activity due to their compact structures. Enzymatic hydrolysis can improve dispersion while modifying structural features relevant to emulsion formation. This study examined how varying degrees of hydrolysis (DH) influence the physicochemical and interfacial properties of mealworm protein hydrolysates (MPHs) and evaluated their effectiveness as natural emulsifiers.

MATERIALS AND METHODS

Mealworm protein solution (1% w/v) were hydrolyzed using Alcalase at 50 °C with 0.5% and 1% (w/w) for 15, 30, and 60 min. The reaction was terminated by heating at 80 °C for 20 min, followed by freeze-drying. SDS-PAGE, FT-IR, circular dichroism (CD), and ANS fluorescence were used to assess peptide fragmentation, secondary structure changes, and surface hydrophobicity. O/W emulsions were prepared with soybean oil, and droplet size, microstructure, and stability were evaluated using DLS, optical microscopy, and Turbiscan analysis. Oxidative stability was assessed by TBARS.

RESULTS

Moderate hydrolysis resulted in clear improvements in colloidal and interfacial behavior. Particle size decreased from ~360 nm in native MP to ~250–260 nm in hydrolyzed samples, while PDI values remained low (~0.2–0.4). The absolute zeta potential increased (−42 mV → −46 to −49 mV), indicating stronger electrostatic repulsion and reduced aggregation.

Secondary structure analysis showed a clear shift, with α-helix content falling from 26.1% to about 10–12% and both β-sheet and random coil components increasing. These modifications enabled MPHs at moderate DH to form smaller and more uniform emulsion

droplets and improved their resistance to thermal and freeze–thaw stress. Emulsions prepared with these MPHs also showed reduced creaming and lower lipid oxidation than those made with native or extensively hydrolyzed proteins.

DISCUSSION

Overall, the functional performance of MPHs reflected a balance between peptide size, solubility, and interfacial activity. Moderate hydrolysis generated peptides that readily adsorbed to the oil–water interface and formed cohesive interfacial layers, whereas excessive hydrolysis produced fragments too small to stabilize droplets or contribute to network formation, resulting in reduced stability.

KEYWORDS

mealworm protein, enzymatic hydrolysis, interfacial behavior, emulsion stability, insect protein.

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