

Maastricht, The Netherlands

ISCCM12

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Oral presentation abstracts

Sunday, November 15, 2026

Opening session

The Biology of Fat: From Metabolic Organ to Cultivated Food

Philipp Scherer

University of Texas Southwestern Medical Center

Adipose tissue is far more than a passive reservoir for energy storage. It is a dynamic organ that regulates systemic metabolism, orchestrates immune responses, remodels the extracellular matrix, and communicates extensively with virtually every other tissue in the body. These biological complexities have important implications for cellular agriculture, where the challenge is not simply to generate lipid-filled adipocytes, but to recreate the structural, biochemical, and functional properties that define authentic fat tissue. Key issues to explore include the fundamental principles governing adipose tissue development, plasticity, and function, drawing on decades of basic research to inform the design of cultivated fat. Opportunities and limitations of current approaches will be discussed, emphasizing the importance of tissue architecture, cellular heterogeneity, and metabolic programming. Understanding how nature builds and maintains adipose tissue will ultimately provide the foundation for engineering cultivated fat that meets both biological and culinary expectations.

Philipp Scherer is Professor and Director of the Touchstone Diabetes Center at the University of Texas Southwestern Medical Center in Dallas. Throughout his career, he has maintained an interest in cellular and systemic energy homeostasis, with a particular focus on adipocytes. His research group was the first to describe adiponectin and endotrophin, both of which are important secretory factors with broad physiological actions and are widely studied by many research groups. Scherer has been on the faculty of UT Southwestern Medical Center since 2007. He has published over 500 papers, which have been cited more than 130,000 times.

Monday, November 16, 2026

Session 1: Tissue Engineering & Biomaterials

Keynote lecture:

Toward Structured Cultivated Meat: Advances in Skeletal Muscle Tissue Engineering

Shoji Takeuchi

The University of Tokyo

Producing structured cultivated meat requires advances in tissue construction, maturation, and large-scale cell production. Our research focuses on engineering three-dimensional skeletal muscle tissues by integrating cell culture, tissue engineering, and microfabrication technologies. We have been developing approaches to construct organized muscle tissues with controlled architectures, while addressing challenges associated with nutrient supply and tissue growth. Improving muscle maturation is another important step toward reproducing the characteristics of natural meat. In addition, scalable cell culture technologies are essential for translating laboratory-scale tissue engineering into practical cultivated meat production. In this talk, I will introduce our recent advances in these areas and discuss how the integration of tissue construction, maturation, and large-scale cell production can contribute to the development of structured cultivated meat.

Shoji Takeuchi received his B.E., M.E., and Dr. Eng. degrees in mechanical engineering from the University of Tokyo, Tokyo, Japan, in 1995, 1997, and 2000, respectively. He is currently a Professor in the Department of Mechano-Informatics, Graduate School of Information Science and Technology, The University of Tokyo. He has authored more than 268 peer-reviewed publications and filed over 140 patents. He led Japan's first national project on cultivated meat and is working toward the realization of cultivated steak meat. His current research interests include cultivated meat, 3D tissue fabrication, bioMEMS, implantable devices, artificial lipid bilayer systems, and biohybrid machines.

Towards model-informed cryobioprinting of porous plant-based scaffolds for cultivated meat

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Structured cultivated meat requires manufacturing strategies capable of controlling not only product shape, but also internal architectures that support nutrient transport, cell maturation and texture development. Cryobioprinting addresses this need by combining extrusion-based deposition with directional freezing, where ice crystals act as transient templates for porous microstructures. Since pore size and alignment are governed by freezing-front dynamics, controlling the thermal gradient provides a route to rational scaffold design.

Here, we present a model-informed cryobioprinting workflow for cellular agriculture, integrating a low-cost open-source bioprinter, a programmable thermoelectric cryostage, phase-change modelling and edible plant-based bioinks. The LusoBioMaker platform provides dual screw-driven extrusion, 2–50 °C printhead control, 365 nm photocuring and 320 N extrusion force, with previously validated printability of 0.995. The integrated cryostage enables directional freezing over an 80 × 80 mm area, reaching −30 °C in ambient laboratory conditions. A two-dimensional phase-change model, first validated using water and embedded thermocouple measurements, is used to design executable temperature trajectories that regulate freezing-front progression and tune average freezing velocity.

As a mechanistic proof of concept, 7.5% GelMA scaffolds displayed aligned and interconnected pores only after ice templating, with longitudinal SEM sections showing temperature-dependent pore diameters from approximately 5–50 μm. Translation to food-compatible materials was demonstrated using pea protein isolate/κ-carrageenan/trehalose bioinks, which showed preliminary cytocompatibility and larger pore-like features up to approximately 150 μm. This workflow establishes freezing-front dynamics as a design variable for tuneable porous cultivated-meat scaffolds and future cell-laden validation under controlled cryogenic processing conditions.

Scalable Bioprinting of Animal-Free Hydrogel Constructs for Co-Culture of Bovine Muscle and Adipose Cells

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The manufacturing of lab-based meat alternatives still faces challenges regarding sustainability, the recreation of genuine meat-like morphology, and the scalable fabrication of tissue constructs. This work addresses all three aspects by establishing the co-culture of bovine muscle satellite cells (MuSCs) and bovine adipose-derived stem cells (bASCs) in a three-dimensional, xeno-free hydrogel matrix. The developed algae- and plant-based hydrogel provides an enhanced amino acid and nutrient profile, containing up to 12 wt% protein, while maintaining desirable extracellular matrix (ECM)-like properties that support sequential and simultaneous differentiation of precursor cells into mature myocytes and adipocytes. Cell adhesion motifs were introduced through RGD-modified gellan gum, improving cell–gel interactions, increasing cell density, and promoting high metabolic activity. Implementation of the bioink in a highly automated and scalable bioprinting technology based on industrial screen printing (3D bio-screen printing; 3D-B-SP) enabled the fabrication of centimeter-scale constructs with accurate bioink deposition and high shape fidelity. Optimization of applied shear forces resulted in high cell viability (>90%) after 24 h of cultivation. Printed hydrogel constructs supported cellular alignment and exhibited a high fusion index (>40%), resulting in contractile muscle tissue. Myosin heavy chain (MHC) and desmin immunostaining confirmed myotube formation, while intracellular lipid staining and increased PPARγ expression demonstrated successful adipogenic differentiation. Overall, the sustainable hydrogel enabled successful co-culture of muscle and fat cells, mimicking the native muscle tissue environment and marbled morphology. Integration with 3D-B-SP offers direct translation potential to industrial manufacturing platforms, with projected production capacities of up to 100 kg h^{-1} per printing line.

Biofabrication of bovine muscle mimics: Leveraging matrix mechanics, anisotropic scaffolds and peptide motifs

David Kilian

MERLN Institute, Maastricht University, Netherlands

Toward scalable structured meat production in vitro, major fundamental challenges must be solved. Two factors in our work that can support growth of muscle fibers are a) harnessing the interaction between muscle satellite cells and tunable biomaterials, and b) leveraging extrusion forces to align biopolymers and muscle fibers.

With dynamic biomaterials designs we can aim to boost bovine muscle differentiation . Using oxidized alginate (2-8 wt%) and dynamic oxime crosslinking by bishydroxlamine, the mechanical properties, i.e. stiffness and stress relaxation of hydrogels can be controlled. An RGD peptide motif mediates adhesion of bovine satellite cells attaching to the matrix. We found that adjusting stiffness from 1-10 kPa and beyond, affects the myogenic differentiation of an immortalized cell line, with increased myotube formation in 6% alginate after 4 days of differentiation. As early myogenic indication, myotubes express desmin and myogenin.

To allow extrusion-based biofabrication of alginate-based bioinks, we blend in food thickeners, methylcellulose (MC) or iota carrageenan (Ci), to tune viscosity and shear-thinning behavior. By controlling extrusion forces and high print speeds, we generate aligned biopolymer structures, confirmed by phase contrast, reflectance microscopy, and optical coherence tomography to visualize 3D patterns. Blending these with plant-based microfibers (zein, lupin), or with recombinant peptides allows further tuning texture, biological activity and protein content in bovine muscle mimics.

Understanding and leveraging cell-material interactions can be a crucial factor for 3D tissue formation. With edible biomaterial designs and novel processing methods, we aim to contribute to an interdisciplinary biofabrication toolbox for scalable cultivated meat production.

Structured Cultivated Meat Biofabrication: 3D Bioprinting Edible Fibrillar Scaffolds for Aligned Myogenic Differentiation

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Fostering the development of cultivated whole-cuts of meat as a future alternative protein source requires strategies that recreate the hierarchical organization and mechanical properties of native muscle tissue. Our research addresses this challenge through extrusion-based 3D bioprinting of edible scaffolds providing structural and mechanical cues that support myogenic differentiation and meat-like texture.

Edible hybrid bioinks were developed using a multicomponent design comprising an alginate (AA)-methylcellulose (MC) hydrogel matrix and lupin or zein microfibers as a dispersed fibrous phase. Among the pilot formulations, 2% AA+4% MC blend exhibited favourable printability, producing uniform filaments (~250–300 μm resolution) and pronounced anisotropic features. Polarized light and reflectance microscopy revealed highly aligned fibrillar microstructures following extrusion, attributed to shear-induced organization of the AA-MC polymer network. To further enhance anisotropy, blow-spun lupin and zein fibres were fragmented via bead milling into short microfibers (~20–30 μm length, 0.5–4.5 μm diameter) and homogeneously dispersed within AA-MC formulations. Following extrusion, the incorporated microfibers aligned along the printing direction, providing additional structural guidance, and a potential route for tuning bioink rheology and mechanical properties through controlled fiber loading. Together, this multicomponent approach combines shear-aligned hydrogel fibrils with reinforcement from microfibers to generate anisotropic scaffolds.

Ongoing work focuses on evaluating the cytocompatibility of these hybrid bioinks and whether the fibrillar microarchitectures can promote aligned myotube formation of immortalized bovine satellite cells (iBSC1). Overall, this work demonstrates the feasibility of generating edible anisotropic scaffolds through extrusion-based bioprinting and represents a step toward scalable biofabrication for structured cultivated meat production.

Monday, November 16, 2026

Session 2: Cell Biology & Cell Line Development

Keynote lecture:

Towards self-organizing steaks with the stem cell zoo

Miki Ebisuya

Physics of Life, TU Dresden

Cultured beef has the potential to provide a sustainable alternative to conventional meat production. While adult stem cells are widely used as the starting material, their proliferative and differentiation capacities are limited. Here, we present the co-induction of skeletal muscle, neuronal, and endothelial cells from bovine embryonic stem cells (ESCs), enabling the self-organization of complex tissue structures in both two- and three-dimensional cultures (ref 1).

Bovine myocytes were induced in a stepwise manner through the induction of presomitic mesoderm (PSM) from bovine ESCs. Muscle fibers with sarcomeres appeared within 15 days, displaying calcium oscillations responsive to inputs from co-induced bovine spinal neurons. Bovine endothelial cells were also co-induced via PSM, forming uniform vessel networks inside tissues. These rapid, serum-free differentiation protocols provide a foundation for engineering self-organizing beef tissue with integrated vasculature and innervation.

More broadly, this strategy should be applicable across mammalian species. Our laboratory has established a stem cell zoo, a collection of pluripotent stem cells from diverse mammals, to investigate species-specific developmental programs (ref 2). Because differentiation proceeds at markedly different rates across species, we propose that developmental tempo is an important parameter for cultured meat production. Selecting species with faster developmental tempo or accelerating the tempo itself could substantially shorten the time required to generate self-organizing meat tissues.

Ref 1: *Sanaki-Matsumiya M, Villava C, Rappez L, Haase K, Wu J & *Ebisuya M. Self-organization of vascularized skeletal muscle from bovine embryonic stem cells. bioRxiv, doi: 10.1101/2024.03.22.586252 (2024).

Ref 2: Lázaro J, Costanzo M, Sanaki-Matsumiya M, Girardot C, Hayashi M, Hayashi K, Diecke S, Hildebrandt TB, Lazzari G, Wu J, Petkov S, Behr R, *Trivedi V, *Matsuda M & *Ebisuya M. A stem cell zoo uncovers intracellular scaling of developmental tempo across mammals.Cell Stem Cell, 30, 938-949 (2023).

Miki Ebisuya did her undergraduate and PhD research at Kyoto University, Japan. After getting her PhD in 2008, she became a group leader at Kyoto University in 2009. Her lab moved to RIKEN in 2013, to the European Molecular Biology Laboratory (EMBL) Barcelona in 2018, and finally to Physics of Life (PoL), Technical University Dresden (TU Dresden) in 2023. Her research group focuses on recapitulating developmental processes using the stem cell zoo, a collection of pluripotent stem cells from various mammalian species.

Smart Engineering of Native Growth Factors in Unagi Adipose-Derived Stem Cells to enable Autonomous Expansion for Cultivated Meat Manufacturing

Andy Tan

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Cultivated meat is increasingly explored as a sustainable protein source to meet growing global demand for meat while addressing concerns of animal welfare and environmental impact. Achieving cost effectiveness of cultivated meat manufacturing requires the development of animal cell lines that are able to expand with minimal reliance on prohibitively expensive serum and exogenous growth factors (GFs). This study aims to engineer an adherent adipose-derived stem cell (ADSC) line previously established from the commercially prized Japanese eel or unagi (Anguilla japonica) to enable autonomous production of unagi-specific GFs that obviate the need for their supplementation in culture media. A modular plasmid design strategy was devised to incorporate native promoter and untranslated region (UTR) elements, that avoid the introduction of xenogeneic sequences, to drive the transcriptional and translational expression of GFs in unagi ADSCs (uADSCs). Candidate promoters were identified through integrative analysis of in-house epigenomic and transcriptomic datasets generated by ATAC-seq, RAMPAGE and RNA-seq together with complementary, publicly available transcriptomic data from juvenile unagi tissues. The activities of identified promoters were evaluated and ranked using transient reporter assays to inform the selection of candidates that promote sustainable production of endogenous GFs. To attain compatibility with scalable bioprocessing platforms, adherent uADSCs are concurrently being adapted to grow in suspension. Collectively, our dual engineering and adaptation approaches are envisaged to support both self-propagating and highly productive cell expansion which ultimately advance the respective economic feasibility and scalability of cultivated meat production.

The stress atlas for cell line characterization

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Intro: Bovine satellite cells (BSCs) have not evolved to grow in steel tanks for cultivated meat production. These cells, however, experience various kinds of stress at scaled-up culture conditions. Currently, there are many efforts to create the perfect environment by improving media formulations and bioreactor designs. In contrast, it is possible to engineer more robust cells to accommodate proliferation in scale-up environments. Therefore, we created a transcriptomic stress atlas to find genetic engineering targets for increased BSC robustness.

Methods: BSCs were cultured under continuous stress for 3 days, after which their RNA was sequenced for transcriptomic analysis. The stressors included 1. waste metabolites (ammonia, lactate, sodium chloride), 2. environmental stressors (temperature, hypoxia) and 3. toxins (antibiotics, DNA damage and apoptosis inducers).

Results: Weighted Gene Co-expression Network Analysis (WGCNA) revealed stressor-specific gene sets, which were especially clear for cells cultured under hypoxic conditions (106 unique differentially expressed genes (DEGs)), heat stress (547 unique DEGs) and ammonium-chloride exposure (796 unique DEGs). For these three stressors a time-course analysis was performed to investigate the onset mechanism of stress reactions.

Discussion: From the stressor-specific differentially expressed genes three engineering targets were picked for three different proof-of-concepts: 1. Increased ammonium chloride resistance by engineering a knock-out cell line, 2. A hypoxia reporter cell line that expresses GFP at lowered oxygen conditions, and 3. Temperature-induced muscle differentiation. These applications show the benefits of data-driven cell line engineering for cultivated meat production; not only for improving cell line robustness but also for cellular agriculture tool development.

Immortalization and Scalable Suspension Culture of Bovine Dedifferentiated Fat Cells for Cultivated Meat

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Co-contributors:
Co-authors (John Yuen, William Balz, Yoshiaki Shimi, and Andrew Stout)

Scalable production of adipose tissue is central to replicating the flavor, texture, and mouthfeel of conventional animal products in cultivated meat. Bovine dedifferentiated fat (bDFAT) cells are a compelling platform for cultivated fat production, owing to their high proliferative capacity and adipogenic potential; however, industrial-scale manufacture demands robust cell lines capable of sustained, long-term proliferation under serum-free suspension conditions.

We report the immortalization of bDFAT cells and their successful adaptation to suspension culture in fully serum-free medium. Transcriptomic profiling across multiple serum and serum-free passage timepoints characterized long-term gene expression dynamics and identified the molecular programs underlying productive adaptation to serum-free media growth. Adipogenic differentiation was further validated directly under suspension conditions, confirming that the intended manufacturing format is compatible with functional fat cell induction. Suspension-adapted lines have obtained over 80 population doublings to-date while maintaining adipogenic competence, with induced cells displaying lipid accumulation and upregulation of canonical.

Scalable bioprocess compatibility was established by successfully cultivating bDFAT cells in stirred-tank bioreactors under suspension conditions. Ongoing efforts toward bioprocess intensification are addressing key scalability challenges, including culture medium optimization and strategies to mitigate inhibitory metabolite accumulation at high cell densities. In parallel, targeted cellular engineering efforts are underway to further equip bDFAT lines with additional functionality relevant to large-scale manufacturing.

Together, these advances collectively establish a well-characterized, serum-free, suspension-competent bDFAT platform with validated adipogenic functionality, providing a scalable cell line foundation for structured fat production in cultivated meat products.

Monday, November 16, 2026

Session 3: Media Development & Utilization

Greener Pastures: Integrating Green Biorefinery Systems with Cultivated Meat Media Production for Sustainable, Plant-derived Media Supplements

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Development of sustainable, cost-effective and animal-free culture media is paramount to CM scale-up. As such, plant hydrolysates have been explored as media supplements to support cell growth and differentiation, whilst replacing undesirable media components such as serum. We have explored the use of grass/clover forage mixes as potential sources of CM media supplements such as free sugars, amino acids and hydrolysates for serum reduction. Furthermore, this work investigates the use of a green biorefinery system to produce these supplements at scale, offering additional benefits to the environmental impacts of media production. Grass/clover-derived compounds were fractionated and, following downstream processing, assessed for their ability to support porcine satellite cell proliferation and performance under reduced-serum conditions. A Life Cycle Assessment was also conducted to evaluate environmental hotspots in the production process and compare to conventional CM media production. Initial results suggest grass/clover-derived supplements may encourage proliferation under reduced-serum conditions. Through use of a green-biorefinery system, co-products have been identified that reduce the environmental burden of these supplements, offering a novel system for producing sustainable CM media. This work highlights the potential value of biorefinery systems in the CM production chain and contributes to the ongoing pursuit of more sustainable and effective CM media formulations.

Cell culture using microalgal derived cultivation media and secreted products from growth factor-producing cells

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Due to concerns about a global shortage of meat supplies, research into novel protein sources, primarily those made from cultured cells, has been spurred. However, because the underlying technology relies on cell culture in laboratories, there are still issues to be addressed, such as the grade of the culture medium, cost, and environmental impact. In addition, the reliance on grains could lead to resource competition with the existing livestock industry and biofuel businesses. To solve these problems simultaneously, we have focused on microalgae as a new nutrient source, and as means to regenerate waste media from animal cell cultures, aiming to establish a circular cell culture system.
To date, we have been developing efficient methods for extracting nutrients useful for animal cells from Nostoc (Trichormus [formerly known as Anabaena] sp. PCC 7120) and improving the quality of the extract through post-processing steps. Furthermore, by genetically modifying Nostoc to secrete glucose, it has become possible to replace the glucose required for cell culture. In this study, we applied an alga-derived culture medium, which achieves grain- and animal-free culture, to growth factor-producing cells to create a conditioned medium, and performed cell cultures of chicken embryo-derived cells (DF-1) and quail myogenic cells (QM7).

Efficacy and variability of canola meal hydrolysate derived amino acids for bovine satellite cell culture

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Co-contributors:
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Cell culture media costs persist as the main cost driver for cultured meat production, and as cultured meat technology advances, the cost and sourcing of amino acids may emerge as a barrier to production scale-up. The addition of hydrolysates in culture media to meet cell-specific nutrient needs or to replenish depleted amino acids during culture can lead to economically feasible scale up and production efficiency of cultured meat. Here, we have developed a plant based hydrolysate derived from the sidestream of canola protein isolate production that yields all 20 amino acids, including high concentrations of four out of the five amino acids that have been reported to be the most difficult to replace with hydrolysates. Currently, this hydrolysate has been validated both as a supplement to and a direct replacement for amino acids conventionally found in Beefy-9 media used to grow bovine muscle satellite cells over multi-passage culture. We also analyze the impact of batch-to-batch variability and upstream canola oil extraction method on the consistency of amino acid composition of the hydrolysates and the efficacy of the hydrolysates in cell culture. The current results point to the potential use of canola meal hydrolysates as a low cost and viable source of amino acids to support cultured meat production as the industry begins to scale.

Development of a fully food-safe medium for high-density fed-batch expansion of animal iPSC

Caitlin Connolly

Roslin Technologies

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The development of scalable, food-safe cell culture systems is critical for the commercialisation of cultivated meat. Induced pluripotent stem cells (iPSCs) represent a promising cell source due to their capacity for unlimited self-renewal and differentiation; however, existing iPSC media are primarily designed for biomedical applications and are not optimised for food production.

Here, we describe the development of a fully food-safe culture medium for porcine iPSC expansion utilising species specific growth factors. We demonstrate its performance in fed-batch stirred-tank bioreactor cultures at 250 mL and 5 L scales over 7–10 day cultivation periods. The medium supported robust cell growth, achieving viable cell densities of up to 25 × 106 cells/mL from an initial seeding density of 0.2 x106 cells/mL, while maintaining high culture viability. Pluripotency following expansion was confirmed by flow cytometric analysis of LIN28, SALL4, and SOX2 expression. Quantitative PCR demonstrated continued expression of NANOG, OCT4, SOX2, and TRIM71. Functional pluripotency was further verified through trilineage differentiation in an undirected differentiation assay.

Successful scale-up from 250 mL to 5 L demonstrated the robustness and scalability of both the medium and fed-batch cultivation strategy. To our knowledge, this is the first report of a fully food-safe porcine iPSC culture medium supporting high-density fed-batch expansion in stirred-tank bioreactors for cultivated meat applications. This work represents a crucial step towards scalable, regulatory-ready manufacturing processes for cultivated meat production.

Tuesday, November 17, 2026

Session 1: Bioprocessing & Scale-Up Technologies

Keynote lecture:

Designing a simple and cost-effective scale-down model: From 20,000 L scale to 50 ml scale

Varun Rajagopal

PARIMA

Operating stem cell cultures at 20,000 L carries severe financial risks. Using real-time off-gas analytics and oxygen transfer modeling, we established a 50 mL shake-flask scale-down model. Across a 400,000-fold scale difference, the system matches large-scale cellular kinetics, dramatically slashing media consumption and development costs

Keep It Simple: Computational scale-up analysis of bioreactor design for cultivated meat production

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Co-contributors:
Marcel Ottens - TU Delft, Lies Levering - TU Delft, Cees Haringa - TU Delft

Scaling up bioprocesses for cultivated meat remains a major technological bottleneck, driven by uncertain requirements for mass transfer, shear tolerance, and mixing performance. We developed a two-stage evaluation approach for conceptual reactor designs. This uses a Monte Carlo–based timescale assessment for initial global screening of feasible stirred tank (STR), bubble column (BC) and airlift reactor (ALR) designs, followed by compartmental modelling to quantify possible gradient formation. Designs were filtered against timescales for mixing, O_2 transfer and CO_2 accumulation while imposing a bubble shear constraint via the Hypothetical Killing Volume (HKV). The analysis identified mixing and O_2 transfer as dominant constraints and showed that geometric optimization and shear protectants can expand the feasible design window.

Guided by these insights, we developed an industrial scale 1D compartment model for ALRs up to 250 m^3. The model resolves height dependent gas hold up, circulation velocities, and local kLa, yielding liquid and gas phase O_2 and CO_2 profiles. The model quantifies starvation and toxicity thresholds that emerge along the reactor height and shows feasible biomass concentrations depend strongly on geometric parameters and cell characteristics. Together, the framework provides a basis for ALR scale up and actionable guidance on cell engineering and operating windows for cultivated meat production.

Sequential Scale-Up (0.5–50 L) of Porcine Induced Pluripotent Stem Cells in Food-Grade Media Without Chemical or Enzymatic Dissociation

Jorge H. Santoyo-Garcia

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The application of induced pluripotent stem cells (iPSCs) in the cultivated meat industry is attracting growing interest due to their genetic stability, high proliferative capacity, and ability to differentiate into myogenic and adipogenic lineages. However, their inherent tendency to form aggregates in suspension culture presents challenges for large-scale bioprocessing, as excessive aggregate growth can result in necrotic cores, impacting process control, scalability, and cost-efficiency. In this study, high cell densities were achieved in a fed-batch suspension process across a 100-fold scale-up from 0.5 L through 5L to 50 L stirred-tank bioreactors without the use of chemical or enzymatic dissociation. Instead, aggregate size was controlled using a standardised mechanical dissociation strategy that was applied consistently throughout the seed train. After 8 days of cultivation in each scale, cell densities exceeded 1.0×10^7 cells/mL, with viabilities maintained above 80% prior to harvest. This corresponded to biomass yields exceeding 15 g/L of wet weight, or more than 500 g of food-safe wet biomass in the 50 L bioreactor. Flow cytometry analysis confirmed the maintenance of pluripotency, with over 80% of cells expressing NANOG, OCT4, and SOX2 throughout the scale up steps. These results demonstrate that a scalable seed train for cultivated meat production can be achieved using food-grade media while eliminating the need for chemical or enzymatic dissociation at each scale-up step, thereby significantly reducing process complexity and cost.

Cross-Functional Scaling: The Modelling Approach for Industrial Robustness for Commercial Cultivated Meat Production

Jan Černý, João O'Neill

Bene Meat Technologies a.s

Co-contributors:
Veronika Juricova

The commercial viability of cultivated meat is heavily restricted by capital expenditures (CAPEX) for facility construction and intense operational expenditures (OPEX) from external supply chains and complex technology with high sterility needs. To achieve market entry manufacturers must gain independence by establishing proprietary process mastery. De-risking commercial-scale production requires a predictive engineering framework that links physical bioreactor environments directly to cellular metabolic states and genomic responses.

This study presents a cross-functional, scaling approach validated using an operational, industrial scale bioreactor. Our integrated development framework was executed with the integration of five foundational pillars: Cell Lines, Growth Medium, Hardware Configuration, Process & SOPs, and final Product Formulation. We present the results of a dynamic bioreactor and cell behavior simulator for fluid shear stress, as well as dissolved oxygen and dissolved carbon dioxide gradients, validated incrementally from 0.5L to 10L, reaching the scale of several cubic meters. Unifying these pillars into a cohesive scaling process increased our know-how, and flexibility required for reaching phenotypic consistency during extended industrial runs.

The multi-scale model incorporated lactate metabolic shifts in scale-up to cubic-meter volumes. Characterizing mechanical stress allowed for the optimization of process, preventing shear-induced cell death. while maintaining optimal gas mass transfer. We also display the impact of the incorporation of in-house hydrolysate production.

Integrating metabolic analytics with physical bioreactor modeling provides a definitive pathway to drive down CAPEX and OPEX by up to 26%. By establishing total process knowledge, this methodology offers a validated, independent blueprint for scaling up commercial cultivated meat production.

Engineering cell cultivation at pilot scale: From conventional scale-Up to kLa-guided process transfer

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Cultivate at Scale

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The successful industrialization of fish cell culture depends on reliable and scientifically sound scale-up strategies that enable reproducible process transfer across bioreactor scales. In practice, scale-up is frequently based on maintaining a single engineering parameter, such as constant specific power input (P/V), agitation speed, or tip speed. While these approaches are straightforward to implement, they often fail to account for the underlying physiological requirements of the cells and may not translate consistently across bioreactors with different hydrodynamic characteristics.

In the poster presentation, we describe two complementary aspects of pilot-scale fish cell process development. First, we demonstrate the successful scale-up of a fish cell cultivation process from 50 to 200 and ultimately 1000 L using a conventional P/V-based strategy. The process showed robust performance at pilot scale and was complemented by downstream processing using a Unifuge Pilot continuous centrifuge, achieving a cell recovery efficiency of 94%. Together, these results demonstrate an integrated upstream and downstream workflow at an industrially relevant scale.

Building on this experience, we developed a more predictive engineering framework for future process transfer based on oxygen transfer performance. The complete 50, 200, and 1000 L bioreactor platform was characterized by correlating the volumetric oxygen transfer coefficient (kLa) with specific power input (P/V) and superficial gas velocity (U_g) using the empirical relationship kLa = A(P/V)^αU_g^β. The reactor-specific parameters (A, α, and β) were experimentally determined for each scale, providing a quantitative basis for selecting operating conditions that achieve equivalent oxygen transfer across bioreactors.

By shifting the focus from maintaining individual operating parameters to satisfying the oxygen transfer requirements of the cultivation process, this methodology provides a more robust and transferable strategy for process scale-up. Combined with the demonstrated pilot-scale manufacturing capability, this work contributes practical tools for de-risking technology transfer and accelerating the industrial implementation of fish cell cultivation

Tuesday, November 17, 2026

Session 2: Nutrition, Function, Formulation, & Sensory Attributes

Keynote lecture:
Muscle tissue engineering for cultivated meat: the Mosa way

Arın Doğan

Mosa Meat B.V.

Co-contributor:
Sergio Spaans, Mosa Meat B.V.

This presentation explores the evolution of muscle tissue engineering at Mosa Meat, detailing the convergent technical and scientific breakthroughs that enabled a bovine muscle cultivation system. We highlight innovations across three domains: custom biomaterial design optimized for satellite cell differentiation, the creation of readouts for measuring output quality and screening for maturation inducers and lastly, engineering novel methods for muscle differentiation bioprocess. Finally, we provide an inside look at how we structured the multidisciplinary research framework to translate tissue engineering fundamentals into cellular agriculture at scale.

Arın Doğan has been leading the muscle tissue engineering team in Mosa Meat for the last seven years. The research adventure started by bringing together a multidisciplinary team of scientists, then adressing fundamental issues of muscle tissue engineering to solve the then unexplored task of making edible bovine muscle tissue.
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Defining the ideal cultured meat profile: extrinsic and intrinsic sensory attributes that drive consumer liking

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Existing cultured meat (CM) studies have primarily focused on technological development and evaluating consumer perceptions. However, the extrinsic (external features) and intrinsic (inherent) sensory attributes driving consumer liking are poorly understood. In this study, consumers (n=112) evaluated a placebo plant-based meat presented as cultured meat sample, to induce perceptions and profile the ideal CM product. Intrinsic attributes were evaluated using Check-All-That-Apply (CATA) and ideal profiling method, while extrinsic attributes through Kano Analysis and ranking. CATA results showed that product liking is positively correlated with buttery, soft, tender, fatty, caramel-like, and juicy attributes. Penalty analysis revealed that fatty, savory, juicy, and tender significantly increased the mean product liking. This confirmed texture's greater influence on product liking than taste attributes. Consumers ranked sensory properties as the most important characteristics of CM, while the use of plant-based materials and advanced technologies in CM production were ranked lowest. Kano analysis aligned with these results; attractive product attributes increasing consumer satisfaction are health benefits and nutritional properties superior to conventional meat, and sensory properties unique to CM. Moreover, indifferent attributes with minimal impact on consumer satisfaction are use of plant-based materials and advanced technologies. Consumer indifference to these CM production technologies suggests consumer openness to these production modifications. This research presents a profile of the ideal cultured meat products through a consumer-driven framework, ultimately providing actionable directions and priorities for cultured meat development to increase consumer acceptance and production efficiencies.

Are we there yet?: A technical roadmap to alternative protein sensory and price parity

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Cultivated meat and other alternative proteins have enormous potential to contribute to a food system that is both tasty and sustainable. For this potential to become a reality, we hypothesize that products need to taste as good or better and cost the same or less than equivalent conventional products. While there are reasons to believe this is feasible, it is also an enormous technical challenge. Our team is developing a technical roadmap describing how we might achieve that goal. The roadmap is intended to communicate which technical solutions will most likely be needed to reach sensory and price parity for different product categories over time, and to facilitate future assessments of technical maturity across the industry. The roadmap highlights the need for coordinated development of technologies and products across cultivated, fermentation-derived, and plant-based proteins and the crucial role that will be played by hybrid products that incorporate two or more of these technologies.

Broadly speaking, reducing cultivated cell production costs will require 1) reduced costs of culture media and other inputs, 2) more efficient conversion of inputs into cultivated cells, and 3) more productive and less expensive bioreactors. Improving the sensory performance of finished products will depend on 1) improvements to the cultivated cells themselves and 2) the development of formulations and post-processing steps for hybrid products. By directly tying research needs to these intended outcomes, this roadmap can help researchers in academia and industry to more clearly visualize how their work helps to build the capacity for real-world success.

3D printed cultured chicken steak: from cells to structure

Diana M. C. Marques

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Cultured meat has the potential to contribute to the global protein production by growing animal-derived cells in bioreactors to produce tissues that resemble conventional meat. For this reason, post-bioprocess product formulation is critical, as the resulting product must exhibit organoleptic (sensory) properties comparable to those of its conventional counterpart.

In this work, we studied the incorporation of 20% (w/w) chicken cell biomass into several plant-based compositions to optimize the final product flavour, aroma, nutritional value, texture and colour. Strategies for developing and combining the chicken cells with the plant-based part, that includes proteins, oils, and fibres were tuned to enhance the chicken cells sensory contribution. This was performed using preliminary sensory evolution tools. Moreover, the final formulation was optimized to allow 3D printing. After that, we performed a full rheological assessment, printability evaluation, mechanical behaviour evaluation, and cooking performance characterization (including water holding capacity and cooking loss) of the chicken inks and the respective raw and cooked 3D printed chicken structures. Different 3D printing infill distances were evaluated, namely 1 mm, 1.2 mm and 1.5 mm. All characterization assays were also performed for conventional factory-farmed and free-range chicken.

Finally, a 3D CAD design of a chicken steak was used to 3D print a cultured chicken steak. The cooking process including time and temperature were defined. Volatile profiling upon cooking was performed, as well as proximate and detailed nutritional composition, in vitro digestion and bioaccessibility assays.

Control of Properties and Nutrient Content of Cultivated Foie Gras Tissues via Scaffold and Media Factors

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Foie gras is a culinary delicacy often criticized for ethical concerns with respect to the method of production which involves significant animal suffering. Recent advances in cellular agriculture offer a promising alternative through tissue engineering, enabling the production of cell cultivated foie gras without the use of animals. The present study developed edible, plant-based 3D scaffolds to support chicken hepatocyte growth toward cultivated foie gras. These biomaterial scaffolds promoted hepatocyte interactions with viability and expression of liver-specific markers. Interestingly, pea-protein-based scaffolds supported significantly greater triglyceride accumulation by the cells than scaffolds prepared from soy protein. The engineered fatty tissues were further analyzed for fatty acid composition, texture (both pre- and post-cooking or extended lipogenesis), and oxidative stability. The fatty acid composition in pea-protein-based tissues was closer to the values in duck foie gras than when grown with soy-protein-based tissues. Cooking or extended lipogenesis reduced the Young's modulus, approaching the mechanics (softness) of traditional duck foie gras, while prolonged storage followed by cooking heightened oxidative susceptibility in pea-protein-based tissues. Two strategies were also implemented to enrich the tissues with α-linolenic acid (an essential ω-3 fatty acid), resulting in a nutritionally enhanced outcome. Overall, this research demonstrates the feasibility of producing cultivated foie gras that mimics the chemical and physical properties of traditional foie gras from duck, while offering improved nutritional benefit and avoids the need for animals in the process, thus advancing the development of sustainable and ethical gourmet foods.

Tuesday, November 17, 2026

Session 3: Environmental & Societal Impacts

Keynote lecture:

Demonstrating safety of cultivated foods from a U.S. regulatory perspective (or how to score a goal on a moving target)

Ricardo Carvajal

Hyman, Phelps & McNamara, P.C.

Ricardo is a director at Hyman, Phelps & McNamara, PC, the largest dedicated FDA law firm in the U.S. He advises food companies ranging from start-ups to multinational companies at all points in the supply chain. He counsels clients on the regulatory status of ingredients and finished products, provides advice on compliance with labeling and advertising requirements, and advises on managing inspections and responding to enforcement actions. His approach to counseling clients draws on insights gained in his former role as an Associate Chief Counsel for foods at FDA.

Prohibiting Cultivated Meat: Understanding the Rise of Cultivated Meat Bans Globally through Regulatory and Discourse Analysis

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Several bans on cultivated meat and other cell-based animal products have been adopted in Italy, Hungary, and a number of US states. These prohibitions are noteworthy because of the public-interest outcomes that cultivated meat may help deliver and which may, in turn, be negatively affected by such bans.

This research examines how bans on cultivated meat and other cell-based foods are framed and constructed in political discourse through an analysis of statements made by politicians in media and parliamentary debates. It investigates both the explicit and implicit objectives underpinning these bans and identifies the dominant themes used to justify opposition to cultivated meat.

The study combines doctrinal legal analysis with discourse analysis. Transcripts of parliamentary debates will be analysed alongside media articles collected in Google News using documented Boolean search strings tailored to each jurisdiction. The collected material will be imported into NVivo and coded inductively to identify emerging themes, frames, and justifications for the bans. In a second stage, the identified themes will be grouped into broader analytical categories to examine how bans are constructed, justified, and contested in public and political discourse.

This study investigates how agricultural interests, cultural values, and established food-related norms shape political debates and regulatory responses to technological innovation. The analysis of cultivated meat bans also contributes to a broader understanding of contemporary gastronationalism by illuminating the relationship between food policy and national identity.

See It, Taste It: Effects of Sequential Exposure and Framing on Behavioural Intentions Toward Cultivated Chicken

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Current consumer research on cultivated meat largely relies on hypothetical online evaluations, limiting understanding of how acceptance evolves when consumers interact with real products. To address the gap, this study examines changes in behavioural intentions across sequential exposure to a commercial cultivated chicken product and packaging framing effects, using a mixed experimental design combining between-subjects and longitudinal components.
In March 2026, 155 young Singaporean meat-eating consumers without prior experience of cultivated meat tasting were recruited (Mage=22.99). Participants were assigned to either visual-only exposure or visual then tasting exposure. Within each condition, participants were exposed to one of four benefit framings (neutral, sustainable, high-protein, combined-benefits). Intentions (taste, buy, substitute, offer, and regular consumption; 0-10 scale) were measured at baseline (T1), after visual exposure (T2), and after tasting (T3).
Baseline intentions were highest for tasting (M=7.92), followed by buying (M=5.73) and substitution (M=4.42). Mixed-effects models (Time and Framing condition as fixed effects; subjects as random intercepts; conditional pseudo-R^2=.405-.784) showed that visual exposure increased taste intention (estimate=0.445, p=.043) but reduced willingness to buy (estimate=−0.671, p=.003), whereas tasting increased purchase (estimate=1.061, p<.001), substitution (estimate=0.671, p=.010), offering (estimate=1.146, p<.001), and regular consumption (estimate=0.793, p=.002).
Framing effects were generally limited, although a significant Time×Framing interaction emerged for substitution intentions (p=.008), with combined-benefit framing increasing substitution after visual exposure (ΔM=+1.00).
Overall, direct sensory experience exerted stronger effects than informational framing, particularly for adoption-oriented intentions. This study provides one of the first experimental benchmarks using a commercially available cultivated meat product, combining real-product exposure with longitudinal mixed-effects modelling."

Beyond Product Attributes: Psychological Determinants of Consumer Acceptance of Cell-Based Seafood

Antonio Borriello

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Seafood consumption worldwide has been rising and is expected to continue increasing as a result of population growth and shifts in dietary habits. Cell-based seafood may serve as a complementary source to capture fisheries and aquaculture in addressing this growing demand. Nevertheless, the sector's long-term viability will depend to a large extent on consumer acceptance.
Research on consumer acceptance has grown substantially in recent years. However, the existing literature has focused predominantly on cell-based meat, while acceptance of cell-based seafood remain comparatively underexplored. Addressing this gap is important, as seafood represents a distinct product category associated with unique consumption habits, sustainability concerns, and quality expectations.
This study investigates the extent to which consumer preferences for cell-based seafood are influenced by psychological determinants, alongside key product attributes such as species, origin, and certifications. Drawing on data from a stated preference experiment conducted among Italian consumers, the analysis examines the role of food neophobia, resistance to change, and consumer innovativeness in shaping purchase intentions. The focus on Italy is particularly relevant, as previous research has identified relatively high levels of resistance towards cell-based seafood among Italian consumers.
By integrating psychological constructs into the analysis of consumer preferences, this study provides a more comprehensive understanding of the factors underlying acceptance of cell-based seafood. The findings can help identify barriers that may hinder consumer adoption and provide valuable insights for the design of targeted communication, marketing, and policy interventions aimed at supporting the responsible development and market uptake of this emerging food sector.

From Priorities to Practice: Building Collaborative Safety Research Infrastructure for Cultivated Meat and Seafood

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Cultivated meat and seafood (CM) offer opportunities to expand sustainable protein production, but safety demonstration remains limited by the lack of standardized methods, harmonized assessment criteria, and publicly available data. The Cultured Meat Safety Initiative (CMSI), co-led by Vireo Advisors and New Harvest, was established to address these pre-competitive challenges through open safety data, collaborative research, and stakeholder coordination. This presentation presents outcomes from six CMSI workshops held in 2024–2026 to develop a coordinated safety research action plan and initiate collaborative projects. The workshops engaged over 100 unique participants from 77 organizations and 18 countries, including approximately 45% academic, 48% industry, 5% government, and 2% other stakeholders.

Workshop discussions refined prior CMSI research priorities into actionable project areas, including culture media and input safety, growth factor assessment, scaffold evaluation, biomapping, manufacturing safety tools, food safety plans, quantitative risk assessment, genetic modification safety assessment, and final product characterization. Across topics, participants identified common barriers, including limited access to industry-representative samples, intellectual property concerns, insufficient funding, and the need for validated analytical methods and shared data systems. To maintain momentum, CMSI has initiated topic-specific working groups, including active efforts focused on scaffold and culture media safety. These working groups are refining research priorities, developing protocols, conducting research, coordinating sample access, establishing data-sharing approaches and databases, and pursuing funding. Together, these efforts provide a foundation for internationally coordinated, pre-competitive multi-sectoral CM safety research that can support regulatory review, commercialization, and consumer confidence.

Poster session abstracts:

Monday, November 16, 2026

Poster Session A

Abstract # 9

From Pint to Plate: Brewing Waste-Derived Bacterial Cellulose as a Cellular Scaffold for Cultivated Meat

Christian Harrison

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Cellular scaffolds are critical for achieving consumer-grade texture in cultivated meat, requiring materials that are inexpensive, biocompatible, and edible. Bacterial cellulose (BC) is a promising candidate, but production traditionally relies on costly synthetic media. This study demonstrates a circular economy approach, utilising waste yeast slurry from breweries as a low-cost feedstock for BC synthesis. Initial results confirmed that waste yeast slurry supported robust BC yield in static culture comparable to standard synthetic media. Characterisation of the BC via Texture Profile Analysis confirmed the production of scaffolds with mechanical properties, including hardness and chewiness, similar to conventional meat products. To address the limited adhesion of mammalian cells (murine fibroblasts) to the BC matrix, we evaluated three passive functionalisation methods: Poly-L-lysine, Vitronectin, and Geltrex. Quantitative analysis via 24- and 72-hour attachment assays revealed that none of these standard coatings significantly enhanced cell attachment, indicating that passive surface adsorption is insufficient for BC scaffolds in cultivated meat applications. To overcome this bottleneck, ongoing work focuses on enhancing cell-matrix interactions through surface charge modification and the creation of inorganic-biopolymer composites. The evaluation of these additional BC functionalisation strategies will be presented, aiming to demonstrate a scalable and cost-effective platform for structured cultivated meat production.

Abstract # 12

Isolation and temporal characterization of a porcine satellite cell population during long-term culture

Anika L. Syroid

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Large-scale expansion of myogenic cells is required for cellular agriculture applications. However, expansion of porcine skeletal muscle satellite cells (MuSCs) currently yields progeny with limited long-term myogenic potential. Therefore, developing methods to isolate porcine MuSCs capable of self-renewal and maintaining myogenicity in culture is essential. We recently identified CD34+NCAM+ MuSCs from mouse skeletal muscle that exhibited these hallmark QSC characteristics during long-term culture. This study aims to establish methods for isolating QSCs from porcine skeletal muscle.

A fluorescence-activated cell sorting (FACS) strategy involving CD34+ is not transferable to isolate a QSC population from porcine skeletal muscle. However, we identified a novel integrin-αlpha7+NCAM+ MuSC subpopulation. Three days post-sorting, these cells exhibited a doubling time of 26.8±1.8 hours, approximately two-fold higher Pax7 expression than C2C12 myoblasts, high Pax7+ cell purity (96.85%), and myogenic differentiation capacity (fusion index: 7%). While proliferation was maintained with extended culture (>100 days), significant reductions in myogenicity occurred, including decreased Pax7 expression (82% reduction from Day 3), reduced Pax7+ cell purity (6.7%), and loss of differentiation (fusion index: 0%). These findings indicate the α7+NCAM+ sorting strategy does not isolate porcine QSCs. Further investigation revealed, myogenic decline occurred within 28 days (not attributable to senescence), coinciding with increased expression of fibro-adipogenic progenitor marker PDGFRα (70.3% PDGFRα+ cells) and adipogenic differentiation capacity. Akin to myogenicity loss, PDGFRα expression and adipogenic differentiation was lost in long-term culture.

This study provides insight on myogenic decline observed during porcine MuSC expansion and underscores the importance of long-term testing to ensure cell source integrity.

Abstract # 14

Amino Acid Requirements in Bovine Satellite Cells Guide Microbial Extract Based Media Design

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Cultivated meat has the potential to serve as a sustainable alternative to traditional livestock farming, yet it has not achieved significant market penetration. Medium costs remain a major challenge, and techno-economic analyses suggest that substitution of fetal bovine serum and growth factors alone will be insufficient to reach commercial viability. Amino acids account for more than 40% of the basal medium costs when supplied as pharmaceutical-grade, high purity ingredients. We aim to replace these amino acids with yeast and bacterial extracts. To rationally design cost effective media, we investigated amino acid dependencies in immortalized bovine satellite cells. Using systematic dropout experiments, we identified several conditionally essential amino acids that are classically categorized as non-essential. Absence of Glycine, Arginine, Glutamine, Proline or Tyrosine led to a reduction in proliferation or no growth after three days. Our findings reveal metabolic bottlenecks that may guide targeted supplementation strategies. Building on this, we are investigating quantitative amino acid requirements for a cell line relevant for the cultivated meat industry and supplying cells with microbe-derived amino acid sources (extracts). This approach could enable the use of food grade, fermentation derived ingredients to reduce both cost and environmental impact of cultivated meat production.

Abstract # 15

Investigating co-cultures for improved cultivated meat production

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To obtain a tissue that resembles the texture and flavour of conventional meat, cultivated meat must contain the different tissue component cell types. This can be achieved by growing and differentiating each cell type separately in monocultures and later combining them through downstream processing. This method increases complexity and production costs. Alternatively, the different cells can be cultivated together using co-culture systems. However, due to the challenges associated with cultivating multiple cell types simultaneously, co-culture methods remain underexplored and mostly limited to small-scale setups. This project aims to investigate co-cultures of bovine fat and muscle cells using scalable systems and assess their feasibility for cultivated meat production.
We first tested the co-proliferation of muscle and fat precursor cells in monolayers. Our results show that the presence of both cell types in the co-culture enhanced their proliferation capacity. Co-differentiation is being investigated to find the ideal settings for both fat accumulation and myotube formation. Several approaches will be investigated to translate the culture in a scalable 3D system. Hydrogels will be used to encapsulate precursor and stem cells to enable proliferation of cells before differentiation to muscle and fat cells. The co-cultures will be translated into small bioreactor cultures to demonstrate the possible translation to industrial bioreactor systems.

Abstract # 16

Identification of Expandable Bovine Satellite Cells for Cultivated Meat Production

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Introduction: Skeletal muscle satellite cells (MuSCs) are a promising candidate for cultivated meat production due to their ability to self-renew and differentiate into muscle fibers. Previously, we demonstrated that murine CD34+NCAM+ cells are a highly pure MuSC population with translationally relevant properties; however, comparable populations in livestock species have not been identified. Therefore, this study aims to identify a bovine MuSC population with similar longevity and myogenic stability to murine CD34+NCAM+ cells. Methods: Cells were isolated from bovine muscle, sorted by fluorescence-activated cell sorting, and characterized in vitro. Results: A bovine CD34+ MuSC population was not identified. Instead, integrin-α7 in combination with NCAM (α7+NCAM+) produced a myogenic population with robust differentiation potential (29.4±12.2% fusion index at passage 5 (P5)). Myogenic characteristics declined over time, demonstrated by declining PAX7 expression and differentiation capacity (14.7±7.6% fusion index at P10). Concurrently, expression of fibro-adipogenic progenitor (FAP) markers PDGFRα and integrin-α5 increased, suggesting α7+NCAM+ cells are heterogeneous. To address this, PDGFRα–α5–α7+NCAM+ cells were isolated through repeated weekly sorting over three weeks. Despite this, a subset of cells re-expressed integrin-α5, suggesting phenotypic transition rather than FAP contamination. Notably, one biological replicate yielded a homogeneous, myogenic population with high expansion potential (PAX7+/MYOD+ at P45), suitable for generating substantial myogenic biomass. Current work involves single-cell RNA sequencing of this population to identify genes underlying these properties and enable reproducible isolation. Conclusion: These findings highlight loss of myogenicity as a major barrier to long-term bovine MuSC expansion while providing a promising population for cultivated meat applications.

Abstract # 17

Changes in proliferative characteristics of gamma-irradiated Hanwoo muscle satellite cells during serial passaging

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Gamma irradiation is widely used for sterilization in the medical and food industries and may serve as a non-genetic approach for modulating cellular functions in cultured meat research. However, its long-term effects on muscle satellite cells remain unclear. This study investigated the effects of gamma irradiation on the proliferative characteristics and molecular responses of Hanwoo muscle satellite cells during serial passaging. Cells at passage 3 (P3) were exposed to 0, 1, 2, 5, or 10 Gy and cultured through passages P4 to P10. Cell number, doubling time, satellite cell markers, cell cycle-related genes, and γH2AX were evaluated. At P4, the 10 Gy group showed reduced cell number and increased doubling time, accompanied by upregulation of p53, p21, and p16, indicating activation of DNA damage responses and cell cycle arrest. In contrast, at P7 and P10, the 2, 5, and 10 Gy groups exhibited higher cell numbers and lower doubling times than the control, together with increased MyoD expression and reduced expression of cell cycle inhibitory genes. γH2AX analysis showed no significant differences among groups at P4 or P7. However, significantly lower γH2AX fluorescence intensity was observed in the 2 Gy and 10 Gy groups at P10, suggesting a reduced proportion of cells with sustained DNA damage signaling during long-term culture. These findings indicate that gamma irradiation initially suppresses satellite cell proliferation but subsequently alters proliferative behavior and molecular characteristics during extended passaging, highlighting its potential as a non-genetic strategy for regulating cell behavior in cultured meat production systems.

Abstract # 18

Bovine Colostrum Whey Enhances Myogenic Differentiation and Partially Supports Proliferation of Hanwoo Skeletal Muscle Satellite Cells

Minjun Kim

Chungbuk national university

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Fetal bovine serum (FBS) is widely used to support muscle cell growth, but its fetal origin, ethical concerns, high cost, and scale-up limitations have driven the search for alternative supplements for cultivated meat production. Bovine colostrum, an early milk secretion supporting neonatal growth, is rich in growth factors such as IGF-1, PDGF, and bFGF, making it a potential source of bioactive components for cell culture supplementation. This study investigated the effects of bovine colostrum whey (CW) on the proliferation and myogenic differentiation of Hanwoo skeletal muscle satellite cells. CW was tested during proliferation under 20% FBS, 10% FBS, and 10% FBS supplemented with 1–3 mg/mL CW, and during differentiation in 2% FBS medium supplemented with 10–2,560 μg/mL CW. MTS assay, cell counting, ELISA, Western blotting, RT-qPCR, immunofluorescence staining, and image-based analyses of myotube formation, morphology, and fusion index were performed. CW improved cell proliferation under reduced-serum conditions, and 2 mg/mL was the most effective concentration among the CW treatments. CW increased IGF-1, PDGF-BB, and bFGF concentrations in the medium, and these concentrations generally decreased after cell culture. CW rapidly increased p-AKT levels within 1 h, with the highest response observed at 6 h, whereas early myogenic marker expression was not markedly increased during proliferation. During differentiation, 40 μg/mL CW increased myotube formation, fusion index, myotube morphological parameters, and myogenic marker expression, whereas higher concentrations reduced these responses. These results indicate that CW partially supports proliferation under reduced-serum conditions and affects myogenic differentiation depending on concentration.

Abstract # 23

A food-derived media supplement supports growth and myotube-like structure formation in a Japanese eel myoblast cell line

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The development of food-compatible media supplements is important for scalable cultivated seafood production. In this study, we evaluated the effects of a food-derived formulation on cell growth and myogenic morphology using a clonal Japanese eel myoblast cell line, JEM1129-A11, as a model system.
Cells were seeded in standard growth medium before the experiment. On day 0, treatment was initiated by replacing the medium with differentiation medium alone or differentiation medium supplemented with the food-derived formulation, an auxiliary factor, or their combination. Phase-contrast microscopic images were obtained on day 0 and day 4, corresponding to the start of treatment and 96 h after treatment, respectively. Morphological changes were assessed based on the orientation, thickness, continuity, and density of elongated myotube-like structures. Compared with the control, the food-derived formulation promoted cell elongation and alignment. The combination with the auxiliary factor further enhanced the formation of organized myotube-like structures, characterized by increased thickness, continuity, and density. These morphological features suggested that the observed effects were not merely attributable to increased cell number, but were consistent with enhanced myogenic differentiation-like morphological changes.
These results indicate that the food-derived formulation may function as a media supplement that supports both growth and myotube-like structure formation in a Japanese eel myoblast cell line. This approach may contribute to the development of food-compatible media strategies for cultivated seafood production. Further quantitative validation using nuclear staining and myogenic marker analysis will be conducted to confirm the effects on cell fusion and myogenic differentiation.

Abstract # 27

Towards cost effective production of cultivated meat through media recycling via removal of Lactate from spent media

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Global meat consumption is expected to reach 73% by 2050 driven by the population growth, according to Food and Agriculture Organization of the United Nations. Cultivated meat (CM) is a sustainable meat alternative with a potential to address food insecurity and environmental issues related to excessive animal farming. CM is produced by growing animal cells in a nutrient-rich growth media within a bioreactor. Once a desired cell density is attained, the cells are allowed to differentiate, mature and assemble to produce meat mimicking the characteristics of natural meat. However, a major challenge is the high production cost, mostly contributed by cost of the growth media. For CM production, media is usually changed before 5 to 7 days due to accumulation of toxic cellular metabolites such as Lactate. This causes all the other expensive unused nutrients in the media to be wasted. This work proposes a novel method to remove Lactate using enzymatic techniques. About 70-90% Lactate reduction was obtained in lactate-spiked growth media. The above studies have also been repeated over multiple cycles to assess the reusability of the technique. Furthermore, cytotoxicity studies showed that cells can still survive with the enzyme treated spent media by utilizing the unused nutrients from the spent media. A better cell growth was also observed when cells were seeded in combination of fresh media and treated media, eliminating full fresh media replenishment. Hence, this work paves a way to reduce the production cost of CM via media recycling by turning waste to a resource.

Abstract # 28

Fundamental Study on Culture Conditions for Large-Scale Expansion of Japanese Eel (Anguilla japonica) Myoblasts

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Background: Culture conditions for Japanese eel (Anguilla japonica) myoblasts remain poorly defined, particularly for suspension culture. Developing scalable culture methods is important for cultivated seafood production. Therefore, this study aimed to evaluate the suitability of microcarrier-based stirred suspension culture for Japanese eel myoblast expansion.
Methods: Immortalized Japanese eel myoblasts (JEM1129; Ikeda et al., 2024) were cultured in a 30 mL bioreactor under stirred suspension conditions. Three culture conditions were evaluated: no microcarrier, PVA-based microcarriers (Scapova), and polystyrene-based microcarriers (Synthemax II). After 7 days of culture, myogenic characteristics were assessed by immunofluorescence staining for MyoD and Pax7, with Hoechst staining for nuclei. Recovered cells were reseeded at high density, and their differentiation potential was evaluated based on morphological changes observed by microscopy. Viable cell numbers were determined by trypan blue exclusion using a hemocytometer.
Preliminary Results: JEM1129 cells expanded under stirred suspension culture in the presence of microcarriers (Scapova and Synthemax II), whereas no significant proliferation was observed under carrier-free conditions. Expanded cells retained expression of myogenic markers, including MyoD and Pax7. Following reseeding, cells exhibited elongated morphology suggestive of myogenic differentiation, indicating preservation of differentiation potential after suspension culture. Ongoing experiments are evaluating differences in cell growth, viability, and myogenic properties among the three culture conditions.
Conclusions: These preliminary findings suggest that microcarrier-based culture conditions enable the expansion of Japanese eel myoblasts and support the development of a scalable culture system. Further studies are underway to optimize culture conditions and characterize expanded cells in greater detail.

Abstract # 31

Transcriptional and protein-based switches for cultivated meat

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Cultivated meat holds promise for creating more sustainable and ethical alternatives to industrial animal farming. However, upscaling and commercialization face major hurdles, since mammalian cells are mostly not well suited for cellular agriculture. Cell-intrinsic features such as limited proliferative capacity, adherent growth, complex growth factor and media requirements and poor differentiation hinder the development of efficient and robust large-scale bioprocesses. These bioprocesses place complex demands on phenotype and cell behaviour and in addition typically follow a two-phase course of proliferation and differentiation. Cells with improved phenotypes and behaviour that can be controlled in time and space are therefore highly desirable. Using immortalized bovine satellite cells (iBSCs) and pluripotent stem cells, we are developing a range of transcriptional and protein-based switches to control cell behaviour in the context of cultivated meat bioprocesses to allow for large-scale proliferation, improved signalling and reduced growth factor requirements and rapid controlled differentiation. These switches can be based on a variety of inputs, including soluble factors or small molecules, or physical stimuli such as temperature or light. Once cell lines carrying these optimized switches are developed, they are characterized using a variety of methods, including AI-based image analysis and transcriptomics. Conversely, imaging data of the generated cell lines can be used to further train phenotype prediction tools and transcriptomic data may reveal candidate genes for further developing and improving transcriptional switches.

Abstract # 32

Functional Characterization of Porcine Fibroblasts from Different Ages and Anatomical Sites and Mechanistic Investigation of Long-Term Passaging Cells

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Fibroblasts play important roles as potential seed cells in cultured meat production; however, their functional heterogeneity and selection criteria remain insufficiently understood. In this study, we systematically investigated the functional diversity of porcine fibroblasts derived from different ages and anatomical sites. The results demonstrated significant heterogeneity among fibroblast populations, with age and tissue origin serving as important factors influencing their biological characteristics. Compared with porcine muscle fibroblasts (PMF), porcine neonatal fibroblasts (PNF) exhibited superior proliferative and migratory capacities, while neonatal fibroblasts (Ne) and nasal fibroblasts (Nf) showed the highest proliferation potential and extracellular matrix (ECM) secretion ability, respectively. Furthermore, fibroblast populations with long-term passaging capacity were successfully identified, and the potential mechanisms underlying their sustained proliferation were preliminarily explored. These findings provide new insights into the regulation of fibroblast proliferation and senescence, and establish a theoretical foundation for the precise selection and stable expansion of seed cells for cultured meat production.

Abstract # 33

Electrical stimulation-mediated myogenesis enhancement of porcine muscle stem cells improves cultured meat quality

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Recent three-dimensional (3D) carriers for cultured meat construction cannot supply the essential physiological signals, leading to the limited cellular myogenesis and tissue maturation. Here, inspired by the endogenous myoelectrical signals, we proposed an electrical stimulation (ES) strategy to assist in vitro cultivation of porcine muscle stem cells (pMuSCs) for cultured meat production. The results showed that 10 Hz ES could promote cell migration, proliferation, and myogenesis under two-dimensional (2D) condition. Therefore, we developed pMuSCs-laden microfibers as a biomimetic cultured meat prototype to demonstrate the application potential of 10 Hz ES in cultured meat production. Benefiting from ES-induced efficient myogenesis, the ES-treated cultured meat tissues demonstrated superior protein content and contraction ability. Interestingly, ES-treated tissues also exhibited a greater diversity of meat-related flavor compounds compared to the non-ES group, such as 1-Octen-3-one, which were also prominently detected in pork but absent in the non-ES group. These features establish ES as a powerful strategy for promoting myogenesis of pMuSCs, also indicating its broad application prospect on high-efficiency and -quality production of cultured meat.

Abstract # 34

Investigating Adipogenesis in Bovine Cells within 3D Bioprinted Microenvironments

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Fat critically contributes to the flavor and texture of meat, making it essential for the development of high-quality cultivated meat products. Due to the currently limited controllability of adipogenesis in bovine cells, the successful production of cell-based adipose tissue for food applications remains challenging.
3D bioprinting provides a valuable platform to investigate chemical and physical effects on cells in three-dimensional environments. Using this technique, we investigate the influence of various printing parameters and the composition of embedded cells on adipogenic maturation of primary cells. This study aims to systematically evaluate how these factors affect cell viability, morphology, and protein expression in primary bovine muscle and adipose cells at different stages of maturation. Three animal-free bioinks were formulated and evaluated for microextrusion printability and cell compatibility, with a particular focus on the behavior of fragile mature adipocytes within these systems. Preliminary studies showed that 14-day pre-differentiated adipose-derived stem cells (ASCs) with noticeable intracellular lipid droplets exhibit a comparable viability after the printing process as mechanically stable undifferentiated ASCs. Based on these results, we aim to develop a co-culture system that allows for controlled differentiation of both ASCs and primary bovine satellite cells in 2D as well as bioprinted 3D cultures. These results are expected to advance cultivated meat research by enabling the integration of functional adipose tissue, improving the reliability of the printing process across maturation stages, and supporting scalable, animal-free bioprinting strategies.

Abstract # 38

Chicken Bone Extract as a Low-Cost Alternative to Fetal Bovine Serum for Cultured Meat Production

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The high production cost of cultured meat remains a major obstacle to its widespread commercialization. In particular, serum accounts for a substantial proportion of the cost of culture media, and reducing serum-related costs is expected to accelerate the practical application of cultured meat.
In this study, we attempted to reduce culture costs by developing a serum-free medium using chicken bone extract, a by-product of food production. Immortalized chicken fibroblast cells (UMNSAH/DF-1, CRL-3586) were used in the experiments. The efficacy of three different culture conditions was evaluated by measuring cell proliferation and observing cell morphology under a microscope: DMEM alone, DMEM supplemented with fetal bovine serum (FBS), and DMEM supplemented with chicken bone extract.
The results demonstrated that the medium containing chicken bone extract supported cell proliferation comparable to that of the FBS-supplemented medium. However, repeated passaging resulted in a gradual decline in the proliferation rate. To overcome this issue, insulin-transferrin-selenium (ITS) was added to the chicken bone extract medium. The addition of ITS restored cell proliferation to a level nearly equivalent to that observed in the FBS-supplemented medium and enabled stable cell growth even after multiple passages.
Future studies will focus on further optimizing the extraction method for chicken bone extract and establishing a more stable culture system that does not require ITS supplementation.

Abstract # 42

Controlling the texture of meat-like cell-based food through enzymatic crosslinking and plant/microalgae additives

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Cell-based food has attracted attention as a sustainable alternative to animal protein. For practical applications, reproducing the appearance, texture, and nutritional properties of conventional meat is a key challenge. However, few studies have reported on the evaluation or control of the textural properties of cell-based food with a meat-like appearance.
In this study, small cell-based food samples were constructed from immortalized chicken embryonic fibroblasts using enzymatic crosslinking with microbial transglutaminase. A meat-like color was reproduced by adding myoglobin, and plant-derived protein (soy protein powder) and microalgae-derived powders (Euglena and Anabaena) were added as texture-improving agents. The use of microalgae is intended to link this work with a circular culture system in which microalgae serve as a nutrient source for animal cell cultivation; here, such microalgae are instead applied directly to the food itself.
Small disk-shaped samples (10 mm in diameter, 2 mm in height) were prepared, and textural properties such as hardness, cohesiveness, and adhesiveness before and after boiling were evaluated by Texture Profile Analysis (TPA) under varying enzyme concentrations and additive types and concentrations. In addition, protein, moisture, and lipid contents were assessed for nutritional evaluation, with chicken meat as a control.
This study aims to clarify how enzymatic crosslinking conditions and additives affect the textural and nutritional properties of cell-based food, and to provide design guidelines for cell-based food combining appearance, texture, and nutrition.

Abstract # 43

Microalgae-Based Nutrient Cycling for Sustainable Cultured Meat Production: Toward a Circular Cell Culture (CCC) System

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Scale-up of cultivated meat production is constrained by the substantial resource inputs required for cell culture media, particularly reliance on nutrients derived from crops grown with fossil fuel-dependent synthetic fertilizers. To reduce this dependency, we are developing a Circular Cell Culture (CCC) system in which microalgae serve as a renewable interface between animal cell culture and inorganic resources.

In the proposed CCC framework, microalgae produce key nutrients—including glucose and amino acids—via photosynthesis to supplement conventional media components. Concurrently, metabolic by-products such as lactate that accumulate in spent culture medium are assimilated and metabolized by the microalgae, enabling medium purification and reuse in subsequent culture cycles.

We are engineering Synechococcus sp., a cyanobacterium, to perform both nutrient production and biological medium purification. Genes associated with lactate assimilation and enhanced glutamine biosynthesis were introduced. Glutamine is the most rapidly consumed amino acid in animal cell culture and is highly susceptible to degradation at elevated temperatures and non-neutral pH; efficient recovery from microalgal biomass therefore represents a key technical challenge.

To evaluate the metabolic performance of engineered strains, cultures were grown for two weeks under illumination with agitation in MA2 medium supplemented with lactate or in DF-1 cell culture-spent medium. Supernatants collected weekly were analyzed by a Cedex analyzer for lactate consumption and glutamine accumulation.

Engineered strains demonstrated efficient removal of lactate and ammonia from spent medium alongside glutamine accumulation. Future work will focus on enhancing glutamine production and evaluating compatibility with animal cell culture to validate the CCC concept.

Abstract # 47

Cross-kingdom support systems for cultivated meat biomanufacturing

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Cultured meat offers a promising option for sustainable protein consumption. However, as production scales up, the increasing volume of waste media generated also becomes an environmental concern. This project explores the possibility of circular media usage, by leveraging on the ease of microbial engineering to develop a support culture for media remediation and reuse.

Our proof-of-concept evaluates different engineered strains for their ability to remove waste products accumulated in spent CHO cell culture media. CHO cells are a well-established animal cell line used in the biotech industry and adapted for suspension growth, presenting a suitable model for cultivated meat cells. One waste metabolite of interest is lactate, due to its inhibitory effect on cell culture growth. To address this, we designed and screened multiple E. coli strains for lactate degradation. Screening successfully identified an engineered strain capable of growth in spent media and enabled complete removal of 20 mM lactate in less than 4 hours. Moreover, we also created and started testing engineered bacterial cells for ammonia removal from spent media. Following microbial treatment and filtration, remediated media will be supplemented with depleted nutrients and reintroduced to CHO cell cultures, establishing an initial workflow for microbe-mediated media recycling.

Beyond the removal of waste products, the use of microbes could be extended to improve other media properties, for instance media conditioning through the secretion of growth factors. Ultimately, this project aims to engineer microbes as a cross-kingdom support system to make cultivated meat a more affordable and sustainable protein option.

Abstract # 49

Stability Assessment and Shelf-Life Determination of Powdered NuMEM Medium Using Physicochemical, Nutritional, and Cell-Based Performance Indicators

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A stability study was conducted to establish an expiry date for powdered NuMEM medium. Three production batches were stored in sealed aluminum sachets under refrigerated (2–8 °C), ambient (18–22 °C/60% RH), and accelerated (40 °C/75% RH) conditions for 12 months. Stability was assessed through physicochemical testing, targeted nutrient analytics, powder characterization, and cell culture performance assays.

A risk-based matrix was used to select stability-indicating markers based on compound lability, biological essentiality, inclusion level, and analytical feasibility. Selected markers included vitamins (B12, B2), amino acids (histidine, lysine, methionine, phenylalanine), calcium chloride, and Maillard-associated lysine degradation. Both total and available amino acids were quantified to distinguish overall composition from bioavailable nutrient fractions. Powder analytics included moisture content, water activity, solubility, pH, osmolarity, and particle-size assessment.

Cell culture performance was evaluated using short-term and long-term proliferation assays with iBSC1 cells. Media functionality was compared with pharma-grade DMEM/F12 controls. Early results demonstrated that accelerated storage caused detectable changes in cell morphology by 4.5 months, indicating loss of performance before major physicochemical failure was observed. Refrigerated and ambient conditions showed substantially better preservation of nutrient integrity and cellular performance over the same period.

The combined analytical and biological dataset provides a robust basis for expiry dating. Preliminary findings indicate that refrigerated and ambient storage best maintains NuMEM stability, while accelerated-condition data support the use of degradation kinetics to project long-term shelf life under recommended storage conditions.

Abstract # 50

Development and characterization of sustainable animal-free scaffolds for cultured fat production

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Cultured meat represents a promising alternative to conventional meat products. Although animal-derived scaffolds provide favorable performances, their use remains inconsistent with the cultured meat main goals. Nevertheless, plant-based scaffolds require improved cell adhesion and tissue regeneration properties, which may be enhanced through incorporation of plant-based proteins. This work aimed to develop mushroom-derived acid-free chitosan films enriched with soybean peptone and yeast extracts as innovative animal-free scaffolds for cultured fat production.
Acid-free chitosan films were produced through a novel procedure, based on water carbonation reversibility and carbon dioxide injection. Soybean peptone and yeast extracts were incorporated into chitosan matrix prior to the solvent casting step. Physicochemical properties and biological performance were evaluated using 3T3-L1 preadipocyte culture and differentiation.
All the formulations exhibited shear thinning behavior, resulting suitable for extrusion-based applications, and the films remained stable in aqueous environment. Indirect cytotoxicity test showed cell viability higher than 70%, confirming effective and complete acid removal during scaffold preparation. Alamar Blue and Live/Dead assays revealed progressive and good 3T3-L1 proliferation. Hoechst/phalloidin staining demonstrated enhanced cell adhesion and adipocytes spread morphology on enriched films likely due to the presence of adhesion amino acid motifs. In contrast, adipocytes on pure chitosan tended to aggregate, reflecting limited adhesion. Oil Red O assay confirmed this trend with a broader distribution of lipid droplets in enriched matrices.
These findings demonstrate the potential of peptone and yeast extracts enriched acid-free chitosan films as animal-free scaffolds for cultured fat production, providing basis for more sustainable and fully animal-free cultured meat systems.

Abstract # 51

Accelerating cell line engineering for cultivated meat through rapid functional screening of CRISPR/Cas editing

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Engineering bovine satellite cells (BSCs) for cultivated meat requires efficient genome editing, yet optimisation of CRISPR/Cas strategies is hindered by poor editing efficiency. Low editing frequencies are often undetectable by bulk assays such as Sanger sequencing, while next-generation sequencing is too costly and time-consuming for fast optimisation of multiple experimental parameters. Here, we present a rapid, flow cytometry-based assay that quantifies genome editing at the protein level within 48 hours, enabling high-throughput optimisation of gene editing protocols directly in BSCs. Using this platform, we systematically screened CRISPR/Cas delivery strategies and found that Cas9 mRNA consistently achieved 80–100% editing efficiency across multiple targets, significantly outperforming conventional plasmid delivery (5–20%). The same trend extended to advanced editing tools, including adenine and cytosine base editors, Cas9 double nickase editors, and Cas12, demonstrating that mRNA delivery consistently enhances editing performance of diverse CRISPR/Cas tools in BSCs. Furthermore, we achieved multiplex editing of four or more loci with Cas9 and adenine base editors at 25–35% efficiency, enabling simultaneous engineering of complex cellular phenotypes. The insights gained from this screening platform directly informed genome engineering strategies targeting process-relevant traits, including lifespan extension through p16 knockout and reduced growth factor dependence through editing of endogenous NRAS. By replacing low-throughput troubleshooting with rapid functional screening, this platform accelerates the implementation of effective genome editing strategies in BSCs. Its straightforward implementation makes it easily transferable to other cultivated meat-relevant species and cell types, enabling faster development of engineered cell lines with industrially relevant phenotypes.

Abstract # 54

Novel porous texturized plant-based scaffold for the fabrication of structured cultivated fish products

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Novel scalable, food-safe, plant-based scaffolds that can support fish cell adherence, growth, and potential differentiation are required to allow the fabrication of cultivated fish products that resemble the textural and nutritional profile of conventional fish products.
In this work, shear cell technology1,2 was used to develop a novel scaffold for cultivated fish applications. Soy protein and pectin were used as the main components to create the texturized fibrous structures. Subsequently, the scaffold's swelling behaviour, degradation rate, and pH fluctuations under different fish cell culture conditions were quantified, using different culture media (DMEM and L15) and temperatures (37oC, 33 oC, and 27 oC). The mechanical and structural properties were studied as well as their biocompatibility with embryonic seabass stem-like cells (DLEC) and seabream cells (Vas13). Fish cell adhesion was successfully confirmed by observing cell behaviour using the Live/Dead assay and proliferation capacity was quantified using Alamar Blue assay. Cell morphology after expansion was analysed after a DAPI/Phalloidin staining. Cell differentiation on the scaffolds was performed and characterized by supplementing the culture medium with a lipid mixture, insulin, dexamethasone and IBMX followed by Nile Red staining. SEM micrographs allowed to observe the cells, the material, the cell-to-cell and cell-to-material interactions within the constructs. Finally, we assessed that textural profile of the final cultivated fish product, and its nutritional value.

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Abstract # 58

Engineering cultured fish via layer-by-layer fibre assembly: unlocking the potential of plant-based fibrous scaffolds

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The development of structured cultured meat and seafood requires scalable, edible and sustainable strategies to support cell growth and organization beyond 2D cultures. One approach consists on integrating edible, plant-based scaffolds that promote cell attachment, proliferation and/or differentiation, while providing structure and texture to the final product. Fibrous structures are especially attractive, given their ability to recapitulate the structural and biological cues of the native extracellular-matrix.
This study presents, for the first time, different plant-based halospuned fibrous scaffolds composed of soy-protein, lupin-protein, mushroom-derived chitosan/lupin-protein, and potato-protein, as potential candidates for promoting seabass cells (DLEC) adherence and growth. All scaffolds were characterized for their morphology via SEM, stability and mechanical (including swelling and degradation rate) performance and biocompatibility. Remarkably, upon Alamar Blue assay and confocal DAPI/Phalloidin staining, we demonstrated that all plant-based scaffolds successfully promoted DLEC proliferation and migration within the scaffold after 11 days. Among the plant-based scaffolds, soy-based scaffolds stood out for promoting higher initial DLEC cell adhesion and greater growth, resulting in 2.22 % (w/w) DLEC cells in the scaffold after 11 days. SEM micrographs confirmed effective cell-to cell and cell-to-material interactions in all scaffolds. Moreover, interactive 3D surface-plots and animated 3D-reconstructions of all scaffolds were produced to better visualise cells migration and interactions.
Finally, we fabricated and cooked a proof-of-concept product to show how such scaffolds can be stacked using a layer-by-layer approach, and explored different strategies on how to integrate these into bioreactor systems (providing multiple conceptual approaches) to produce hybrid cultured seafood products.

Abstract # 61

Continuous Label-Free Quantification of Adipogenic Differentiation

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Accurate quantification of mesenchymal stem cell proliferation and adipogenic differentiation is essential for cultivated fat production. However, conventional endpoint assays fail to capture the dynamics of these processes. Label-free live-cell imaging, combined with automated image analysis, enables continuous, non-invasive quantification over time.
Here, we present a comparative analysis of a device-integrated live-cell imaging analysis pipeline and custom-trained Cellpose segmentation models for label-free quantification of proliferation and adipogenic differentiation in human and porcine mesenchymal stem cells (MSCs).
Both approaches enabled robust determination of cell number and confluence during proliferation. During adipogenic differentiation, both methods successfully quantified adipocytes but differed in their segmentation strategies. The device-integrated analysis primarily detected contrast-rich regions associated with mature adipocytes, while the model segmented individual adipocytes, enabling quantification of both adipocyte area and number and allowing earlier detection of differentiation events. Custom-trained models demonstrated adaptability across species and imaging modalities, including manually acquired brightfield images.
Overall, label-free image analysis reduces experimental effort, avoids staining-related artefacts, and enables time-resolved characterization of cellular processes. While device-integrated analysis offers ease of use and seamless integration, Cellpose models provide superior flexibility and applicability, highlighting their complementary strengths for advanced cell culture analysis.

Abstract # 62

Low-Cost Alternative Iron Delivery Strategies as Transferrin Replacements in Serum-Free Culture of an Immortalized Bovine Fibroblast Line

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Transferrin is widely used as an iron carrier in serum-free media, but its cost and limited scalability pose significant challenges for cellular agriculture applications. This study evaluated six candidate iron delivery strategies - including small synthetic iron chelators - as potential transferrin replacements in an immortalized bovine fibroblast line under serum-free conditions. Candidates were screened in 96-well plates across multiple concentrations, then confirmed in T25 flasks over four passages. Cellular performance was assessed by cell count, viability, doubling time, and morphology, benchmarked against a transferrin-supplemented positive control and a transferrin-free negative control. Lead candidates were validated in aggregate suspension and scaffold-based tissue culture systems. Without transferrin, cells failed to sustain culture beyond passage 2, confirming iron dependency. One candidate, a low-cost small synthetic chelator, fully supported proliferation and viability across all four passages at levels comparable to the transferrin control (viability 92–96% vs. 93–95%; cell counts 2.7–3.4 x 10^4 vs 3.1–3.9 x 10^4 cells/cm^2). A second candidate sustained culture through all four passages with viability of 92–96%, but with lower and more variable cell counts, averaging approximately 1.9–3.9 × 10^4 cells/cm^2 vs. 3.1–3.9 × 10^4 for the transferrin control. The remaining four candidates did not sustain equivalent growth. The small chelator candidate can functionally replace transferrin in serum-free bovine fibroblast culture with no apparent cytotoxicity, demonstrating feasibility of low-cost synthetic iron delivery. Ongoing work addresses compound stability and performance in high-density suspension culture, with implications for scalable, cost-effective serum-free media formulations across cell culture applications.

Abstract # 64

Exogenous DNA sensing and stress pathways as targets for improving bovine cell engineering in cultivated meat

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Cultivated meat production relies on robust, scalable cell lines that can support industrial-scale manufacturing. Genetic engineering offers a direct route to improve traits for culture performance such as growth, differentiation, and suspension adaptation. For this process to be efficient it requires cellular backgrounds that can tolerate exposure to exogenous DNA. However, bovine satellite cells often exhibit poor tolerance to exogenous DNA delivery, limiting both genetic engineering efficiency and the development of optimized cell lines.

To investigate the basis of this response, immortalized bovine satellite cells (iBSCs) were subjected to plasmid electroporation and analyzed by RNA sequencing. Differential expression analysis revealed a strong transcriptional response to exogenous DNA delivery, characterized by activation of innate immune sensing, Type I interferon signaling, and cellular stress-response pathways, potentially involving non-canonical mechanisms of interferon induction. In contrast, electroporation alone induced minimal transcriptional changes, suggesting that intracellular recognition of plasmid DNA, rather than the electroporation process itself, is the primary driver of the observed response. Pathway-level analysis further indicated activation of transcriptional programs associated with antiviral defense, inflammatory signaling, growth arrest, and cellular stress, linking exogenous DNA sensing to reduced cell fitness post-transfection. These findings identify cytosolic nucleic acid sensing and downstream interferon signaling pathway components as potential engineering targets for improving tolerance to genetic engineering approaches.

This work provides a mechanistic framework for the development of DNA stress-tolerant iBSCs to support the expansion of genetic engineering toolkits and accelerate cell line development for cultivated meat applications.

Abstract # 65

Exploiting Mechanobiology to Stimulate Myogenic and Adipogenic Differentiation

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Current methods to differentiate cells towards a myogenic or adipogenic phenotype primarily employ chemical additives and specialist media compositions. Use of such additives within cultivated meat can generate regulatory barriers, safety concerns and damage public acceptance of products.

Other approaches, for instance stimulating the mechanobiological response of cells, offer an interesting avenue for chemical-free differentiation and proliferation. Such responses can be triggered by applying nanoamplitude vibration to cultures, a process with demonstrated success to induce differentiation of mesenchymal stem cells down osteogenic lineage.

This work focuses on the proliferation and differentiation capacity of vibration for the cultivated meat industry, characterising for the first time its effects in serum-free conditions. More specifically, DF-1 embryonic chicken fibroblasts were exposed to 14 days of 30 nm vertical vibration and the resultant effects on myocyte and adipocyte differentiation were assessed through immunofluorescent staining and flow cytometry of differentiation markers MYOD and PPARγ. Vibration was delivered via specialised bioreactors designed by the University of Strathclyde that utilise piezo actuators to facilitate vibration. Preliminary results indicate that 10 days of 10 kHz nanovibration can significantly increase DF-1 proliferation in serum-containing conditions. Additionally, increases in proliferation under 10 kHz vibration in serum-free conditions can be realised as early as 3 days. The cellular changes induced through weaning were also characterised fully through proliferation, viability, and morphological analysis through flow cytometry, microscopy and immunofluorescent staining.

The potential of vibration to differentiate cells at scale without chemical additives has the potential to transform large scale food bioprocessing.

Abstract # 69

Comparative assessment of different extracellular matrix protein coating on in vitro expansion and preservation of stemnenss of primary bovine satellite cells

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Satellite cells are essential for scalable cultivated meat production due to their intrinsic differentiation potential to form the myofibres. In their biological niche, activation and differentiation of satellite cells largely relies on the signal received from the surrounding cells and extracellular matrix (ECM). Various ECM proteins such as collagen, laminin, fibronectin, vitronectin and gelatin promote cell adhesion, proliferation and differentiation and thus, are used as coating materials to grow satellite cells. Previous studies suggest that satellite cells from different species behave differently with different ECM proteins, so it is imperative to select efficient and cost-effective ECM coating for large-scale culture of satellite cells. In this study, we investigated the effect of five ECM coatings- fibronectin, vitronectin, collagen, laminin, and gelatin on in vitro expansion (proliferation rate) and preservation of stemness (Pax7 expression) of primary bovine satellite cells (BSCs). Proliferation rate (cell number and doubling time), cell viability (MTT) and gene expression of myogenic markers (qRT-PCR) were assessed. BSCs grown on collagen and gelatin coating showed highest proliferation rate while collagen coating showed highest viability of BSCs followed by fibronectin and gelatin coating. Moreover, BSCs grown on gelatin coating showed higher Pax7 and myogenic gene expression than cells grown on other coated dishes. Future work involves the comparative assessment of effect of five coatings on long term culture (mutli passage) and differentiation of primary BSCs. In conclusion, our comparison of coating revealed that collagen and gelatin have the potential to serve as suitable coating for growing BSCs for cultivated meat application.

Abstract # 71

Recombinant Proteins as Cell Recognition Cues for Engineered Cultivated Meat Scaffolds

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A fundamental challenge in the production of structured meat products is the development of biomaterial scaffolds that: a) provide structural support and b) facilitate favorable cell-material interactions. With tunable scaffold designs, we aim to mimic important extracellular matrix (ECM) constituents (laminin, elastin, collagen, fibronectin) that support muscle cell adhesion, maturation, and 3D tissue formation. Recombinant elastin-like proteins (ELPs) can serve as versatile supplements for such scaffold designs. Defined peptide sequences enable the incorporation of precise cell-recognition motifs to tune biochemical and mechanical properties of cell-compatible polysaccharide scaffolds (e.g. alginate).
In this study, we investigate conditions for bacterial expression and characterization of recombinant ELPs engineered with specific, matrix-mimicking cell-recognition sites. ELP constructs are produced in engineered Escherichia coli, followed by cell harvesting and protein extraction via cellular lysis. Purification is performed using Inverse Temperature Cycling (ITC), leveraging the reversible phase transition behaviour of ELPs to enable efficient and cost-effective isolation.
The yield and purity of obtained proteins are evaluated using standard biochemical characterization methods (e.g. semi-automated western blot). Subsequently, their cell-adhesive and cell-supportive performance is assessed in vitro using bovine muscle satellite cells, by quantifying cell attachment, spreading, and differentiation. These analyses provide insight into how the incorporation of specific recognition motifs influences cell-material interactions. Selected peptide designs are blended with naturally derived biopolymers (e.g. alginate) to generate protein-supported hydrogel scaffolds for 3D muscle cell culture. Such blends will also allow tuning the rheological properties of recombinant ELPs towards viscosity-adjustable bioinks for scalable processing and fabrication of structured cultivated meat products.

Abstract # 74

Sustainable bioink engineering of extrusion-3D printed scaffolds for cultivated meat

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Cultivated meat requires reproducible, structurally robust scaffolds capable of supporting cell attachment, proliferation, and tissue maturation. This study investigates extrusion-based 3D printing for scaffold fabrication, focusing on bioink processing, printability, structural stability, and sustainability. Protein- and polysaccharide-based bioinks, including sunflower protein–alginate and silk fibroin–alginate formulations, were developed through material preparation, extrusion testing, and scaffold fabrication.

Bioink performance was assessed in terms of ink rheological behaviour, print fidelity, and post-printing stability under cell-culture-relevant conditions. Printing parameters were screened using nozzle diameters of 200-400 μm, a printing speed of 5 mm/s, extrusion rates of 0.5-1.5 μL/s, and infill densities of 20-40%. Sunflower protein–alginate and silk fibroin–alginate bioinks demonstrated favourable extrusion behaviour and reproducible scaffold formation, although powder processing was required to improve particle uniformity, enhance dispersion, and reduce nozzle clogging.

Stability testing showed an initial scaffold mass loss of 12.1 ± 4.1% after 5 min in culture medium, followed by swelling and mass recovery. After 240 min, scaffold mass increased by 11.5 ± 3.9% relative to the initial mass, indicating short-term structural stability rather than progressive degradation. Rheological analysis showed that silk fibroin–alginate recovered 77.15% of its viscosity after shear, confirming shear-thinning behaviour and post-extrusion recovery for stable filament formation and layer deposition.

Ongoing work combines scaffold structural characterisation, cell-culture evaluation, low-cost culture-medium assessment, and literature-based CO_2-emission analysis to link processing, scaffold design, biological performance, affordability, and sustainability. These findings support optimising bioink composition, scaffold geometry, and processing efficiency for scalable, resource-conscious scaffold development.

Abstract # 83

Livestock primary cells as source of muscle and fat for structured cultured meat.

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Cultivated meat has emerged as a valid alternative to traditional meat production, offering environmental and animal welfare benefits. This technology aims to reproduce the nutritional and organoleptic properties of conventional meat1. Achieving this, and moving towards scaled-up production, requires high proliferation capacity and proper differentiation of muscle and adipose cells.
To generate a structured cultivated meat prototype, we used a core/shell 3D bioprinting system that enables cell deposition in a layer-by-layer manner, producing a 3D structure of oriented hydrogel fibres2. This approach relies on a microfluidic printing head (MPH) with a coaxial nozzle, allowing simultaneous deposition of a fibrinogen core matrix embedding the cells, surrounded by an alginate shell. The core/shell system enables the printing of fibrinogen, a gold-standard matrix for muscle cells, despite its disadvantageous rheological properties. This system supports muscle cell growth within a soft matrix, promoting their alignment and fusion into muscle fibres, and replicating the highly organized architecture of skeletal muscle tissue. The printing parameters were further optimized for differentiation of adipose progenitor cells.
Building on preliminary evidence of our muscle precursor cells to growth in suspension, we investigated their behaviour under low-adherence conditions and in small-scale bioreactors, to assess their potential as a scalable cell source.
Overall, our work demonstrates the capacity of our 3D bioprinting system to sustain the differentiation of muscle and adipose progenitors into structured constructs for cultivated meat applications and characterizes the growth in suspension of primary livestock cells as a potentially scalable cell source.

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2. Reggio, Alessio, et al. "3D Rotary Wet‐Spinning (RoWS) Biofabrication Directly Affects Proteomic Signature and Myogenic Maturation in Muscle Pericyte–Derived Human Myo‐Substitute." Aggregate 6.4 (2025): e727.

Abstract # 88

Engineering Tunable Viscoelastic Hydrogels to Regulate Bovine Myogenesis for Cultivated Meat

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Cellular agriculture aims to produce animal-derived products by cultivating cells in controlled environments, offering more sustainable alternatives to conventional meat production. A major challenge is promoting efficient muscle differentiation, which the development of new biomaterials resembling the dynamic environment of the native muscle matrix might facilitate. Most currently available substrates are mechanically static and do not replicate the viscoelastic environment required for optimal myogenesis. While matrix stiffness and stress relaxation regulate muscle development in several species, their influence on bovine muscle cells remains largely unexplored. Here, we investigate how viscoelasticity affects bovine myogenesis to guide the design of dynamic substrates for cultivated meat.

Oxidized alginate (OA), a food-grade polysaccharide, was crosslinked using dynamic covalent crosslinkers (bishydroxylamine and dihydrazide) to produce hydrogels with tunable stiffness and stress relaxation. The mechanical properties of the materials were characterized by rheology (TA Instruments), generating a library of viscoelastic hydrogels with defined stiffness (1 – 25 kPa) and stress relaxation profiles. Immortalized bovine satellite cells (iBSC1) were cultured on these matrices, and cell growth was assessed microscopically through confluency and EdU incorporation. Myogenic differentiation levels were evaluated by immunocytochemistry and RT-qPCR using sequential myogenic markers (desmin, myogenin, and myosin heavy chain).

Our results demonstrate a stiffness-dependent response, with 10 kPa hydrogels promoting enhanced myogenesis, shown by increased numbers of desmin- and myogenin-positive cells compared to other tested conditions. Ongoing work is exploring stress relaxation effects on myogenesis of cells grown on customized microcarriers for bioreactor cultures. Together, these findings provide insights into how matrix mechanics regulate bovine muscle cell differentiation and support the development of food-grade, scalable biomaterials for cultivated meat production.

Abstract # 90

Beta-lactoglobulin in whey replaces albumin in cell culture

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Serum-free cell culture often relies on the use of blood-derived albumin or recombinant albumin. Variation in bioactivity and economical and ethical considerations require albumin to be replaced, especially for industries which culture cells at large scale like cultured meat and vaccine or antibody production. Many functions have been attributed to albumin, which has hampered the successful discovery of a functional replacement. Here we report a progressive screening pipeline yielding whey protein isolate as an albumin replacement, which was validated in a bioreactor culture of bovine fibro-adipogenic progenitor (FAP) cells. Further investigation indicated that the effect of commercial WPI can be explained by the combination of β-lactoglobulin (βLG) and sunflower lecithin. Recombinant βLG was found to be equipotent to milk-derived βLG, and the albumin-replacing effect was validated in cells from mammals, birds, and fish. These findings provide a robust, cheaper, and animal-friendly alternative to the use of albumin in (large-scale) cell culture.

Tuesday, November 17, 2026
Poster Session B

Abstract # 5

Assessing the sustainability and socioeconomic implications of cultured cattle meat through a Multiregional Input–Output Approach

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The meat industry is a major source of environmental pressure, accounting for around 12% of global greenhouse gas emissions, with beef production being a key driver of deforestation, land use and water stress. In the context of rising global food demand, alternative protein sources such as cultured meat arise as a pathway towards sustainable food systems. Most existing assessments of the impacts of cultured meat focus on direct production processes, while the broader effects transmitted through global supply chains remain largely unexplored. This study addresses this gap by evaluating the environmental and social implications of replacing conventional beef with cultured meat, explicitly accounting for global supply-chain effects through a multiregional input–output model.
Our results indicate substantial environmental benefits of cultured meat compared with conventional beef. Cultured meat could significantly reduce agricultural greenhouse gas emissions, mainly by eliminating emissions associated with enteric fermentation and livestock feed production. Additionally, pressures related to water scarcity and land use would decrease around 120% and 180%, respectively. However, cultured meat production leads to considerably higher combustion-related emissions, highlighting the importance of low-carbon energy systems. Nevertheless, total CO_2-equivalent emissions remain higher for conventional beef. From a social perspective, while cultured meat production generates higher-skilled jobs, it implies the loss of low-skilled employment linked to conventional cattle production. Overall, the results suggest that the large environmental gains associated with cultured meat could be accompanied by significant employment shifts, underscoring the need for compensatory policies to ensure a fair and inclusive transition of the food production system.

Abstract # 8

CROSSing socio-political barriers in PROtein innovation

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Alternative proteins, such as cultivated meat and products derived from biomass and precision fermentation, have significant potential to contribute to the sustainability transition of the European Union's (EU) food system. By reducing reliance on conventional animal agriculture, these innovations could help mitigate the environmental and social impacts associated with livestock production. Despite these potential benefits, political debates across the EU often portray alternative proteins as a threat to established food cultures, emphasizing their perceived unnaturalness and questionable economic viability. Such narratives position alternative proteins in opposition to traditional foods and are frequently promoted by incumbent actors within the agri-food sector.

CROSSPRO aims to provide a comprehensive analysis of how opposition discourse influences policies concerning the development and commercialization of alternative proteins in the EU. The first part of the project involves mapping relevant policy instruments at both EU and Member State levels and conducting a systematic analysis of opposition discourses in selected national contexts. Building on these findings, the second part of the project will develop targeted policy recommendations to address stakeholder concerns and support a just and inclusive transition for consumers and food players currently dependent on conventional animal agriculture, including farmers and rural communities.

The novelty of CROSSPRO lies in its interdisciplinary approach, which combines legal analysis, political science, consumer studies, and food studies to investigate the complex factors shaping the adoption of alternative proteins in the EU.

Abstract # 11

Myogenic Cell Expansion on Porous Gelatine Microcarriers: Optimisation and Scale-Up for Cultivated Meat Bioprocesses

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Efficient large-scale expansion of muscle progenitor cells remains a key bottleneck in cultivated meat production. We evaluated Cultispher-S, a porous gelatine-based and potentially edible microcarrier (MC), as a proof of concept for myogenic cell expansion within stirred bioreactors, addressing bioprocess performance and food safety requirements.

C2C12 myoblasts adhered, spread, and proliferated within the porous structure of Cultispher-S. We identified the optimal seeding density ensuring homogeneous colonisation and minimal aggregation in spinner flask cultures. Notably, MC concentration could be increased up to 16-fold above the manufacturer's recommendation without compromising cell proliferation. Final cell densities plateaued at equivalent values (~1.4×10^6 cells/mL) across all MC concentrations tested, suggesting that yield might be primarily nutrient-limited rather than surface-area-dependent under these conditions.

To further enhance performance, we compared single-batch versus sequential MC addition strategies. At high MC densities, single-batch addition reduced the initial growth rate, likely due to excess surface area at inoculation; sequential addition over multiple days mitigated this effect and tended to mildly reduce end-of-run aggregation, while both strategies reached equivalent final cell yields. Metabolic data consistently pointed to nutrient limitation as the primary growth constraint, highlighting the need for feeding regime optimisation.

These findings demonstrated that porous gelatine MCs could successfully sustain myogenic cell growth, providing a strong foundation for edible-MC-based cultivated meat platforms. Future work will scale up this process to 2L bioreactors, extend it to non-porous edible gelatine MCs and primary bovine satellite cells, and apply AI-driven feeding optimisation to establish design principles for scalable muscle cell manufacturing.

Abstract # 20

Commercializing Cultivated Meat: The Role of Public Policy in De-Risking Private Capital

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Cultivated meat may become a competitive and sustainable alternative to traditional animal agriculture to meet growing demand for meat and diversify the food supply in the United States. However, the industry is currently stalled between pilot demonstration and commercial scale. Existing research demonstrates that the United States government has played an essential role in supporting the commercialization of many critical industries. This paper examines how United States public policy shapes the commercialization of emerging deep technologies by de-risking private investment, applying this framework to the cultivated meat industry. It argues that the commercialization of cultivated meat is not limited primarily by technological feasibility, but by access to capital. It suggests that public policy can enable commercialization by reducing key risks and mobilizing private investment. It does so by combining a conceptual commercialization framework, a novel investment viability scorecard, and a comparative case study of the United States electric vehicle industry, supported by descriptive data analysis and policy evaluation, to identify how public policy reduces key risks and enables private capital formation.

Abstract # 22

Consumer's Perception of Cultivated Meat in Canada

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With continued population growth and increasing concerns about global food security, cultivated meat has emerged as a potential sustainable food source. In addition to reducing pressure on agricultural resources, cultivated meat may offer environmental benefits and improve animal welfare. However, consumer acceptance remains a key challenge to its successful adoption. Therefore, this study examines contemporary consumer perceptions of cultivated meat in Canada. The research addresses three main questions: What are Canadian consumers' current perceptions of cultivated meat? How does benefit framing, such as animal welfare and environmental benefits, influence consumer acceptance? How do demographic factors, including gender, age, and education, affect willingness to choose cultivated meat?
Data will be collected through a nationwide survey of approximately 3,000 Canadian residents aged 18 years or older who are comfortable communicating in English or French. The sample will be designed to reflect the Canadian population in terms of region, age, and gender. Survey questions will gather information on demographic characteristics, dietary habits, and attitudes toward cultivated meat.
To minimize bias, product descriptions will use neutral and informative language. Choice scenarios will vary by benefit framing (animal welfare, land-use reduction, and lower carbon emissions) and product naming (cultured meat, cultivated meat, and lab-grown meat). A Conditional Logit Model will be used to estimate the probability of choosing cultivated meat based on product attributes and consumer characteristics. The findings will identify the framing strategies and product attributes that most strongly influence Canadian consumers' acceptance of cultivated meat.

Abstract # 26

A Scaffold-Based Packed-Bed Culture System with PDMS-Mediated Gas Exchange for Scalable Cellular Agriculture

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A primary limitation in scaling cell-cultured food is the lack of specialized hardware capable of maintaining high-quality, consistent production yields. Bench-top systems often fail to scale effectively without compromising cellular output. To address this, we tested a 0.2 L Oxy Thru cultivator designed to accommodate the distinct metabolic demands of diverse species in cellular agriculture. The system pairs a gas-permeable PDMS (polydimethylsiloxane) vessel wall for gas exchange with a packed-bed culture format that uses edible scaffolds, increasing the surface area available for adherent cell growth. We evaluated three cell lines spanning distinct lineages: avian (DF1), ungulate (MDBK), and teleost (FHM CCL-42). Preliminary data demonstrate that all tested cell types proliferated within the packed-bed system, achieving significantly higher viable and total cell number per gram of scaffold than in the static 100 mL Cultistir polystyrene reactor. This performance across multiple species may be attributed to the combination of enhanced gas transfer through the PDMS material and the edible packed scaffold. These results suggest that this approach may effectively bridge the gap between bench-scale research and industrial scalability for cultivated meat production.

Abstract # 29

From Cultured Fish Meat to Food Products: Technology Pathways, Flavor Regulation, Digestive Characteristics, and Industrialization Prospects

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Cultured fish meat represents an important direction for future foods and alternative proteins, with broad prospects in sustainable resource utilization, food safety assurance, and precision nutrition. Focusing on the transition “from cultured fish meat to food products,” this report systematically explores food-oriented technology pathways, flavor regulation, digestive characteristics, and industrialization prospects.

The report will focus on analyzing the flavor characteristics of cultured meat derived from different fish species, the formation mechanisms of tissue structures in different product formats, and their adaptability to food processing. It aims to clarify the key technical challenges involved in transforming cell-cultured fish meat from laboratory-scale samples into edible food products. Meanwhile, by considering factors such as the accumulation of flavor precursors, lipid oxidation, thermal processing reactions, and texture construction, this report will discuss the mechanisms of flavor formation and regulation strategies for cultured fish meat products.

In terms of nutrition and digestive characteristics, the report will focus on protein composition, in vitro digestion behavior, and the evaluation of potential nutritional bioavailability, thereby further revealing the nutritional quality and edible value of cultured fish meat. This report aims to provide theoretical references and practical insights for the food development, quality improvement, and industrial translation of cell-cultured fish meat.

Abstract # 30

GLP-Compliant In Vivo Safety Evaluation of a Cultivated Pork Product: Evidence Generated Under the Korean Regulatory Framework

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As cultivated meat approaches commercialization, publicly available in vivo safety data remain scarce despite growing commercial momentum. Here, we present a rare GLP-compliant toxicological dataset generated under the Korean regulatory framework. Although safety assessment strategies differ internationally, many regulatory approaches primarily emphasize compositional and manufacturing-based assessments, whereas Korea requires GLP-compliant toxicological evidence for cell-cultured food ingredients (i.e., cultivated meat products) under its novel food ingredient evaluation framework.

To satisfy these regulatory requirements, we evaluated a cultivated pork product derived from porcine muscle stem cells using OECD-compliant acute and 13-week repeated-dose oral toxicity studies in Sprague–Dawley rats. The test substance was administered orally at doses up to 2,000 mg/kg/day, with conventional pork serving as a reference comparator.

No mortality, treatment-related clinical signs, or toxicologically relevant changes in body weight, food consumption, clinical pathology, organ weights, or histopathology were observed. Isolated statistically significant findings lacked dose dependency and biological relevance, and no treatment-related target organs were identified. The no-observed-adverse-effect level (NOAEL) was established at 2,000 mg/kg/day, the highest dose tested.

Beyond supporting the safety of this specific product, this study demonstrates how data generated to satisfy national regulatory requirements can contribute to the broader scientific evidence base for cultivated meat. As GLP-compliant datasets accumulate across products and production platforms, they have the potential to facilitate the development of scientifically grounded and internationally harmonized safety assessment frameworks, and to inform future discussions on whether routine in vivo testing remains warranted or can be replaced by scientifically justified alternatives.

Abstract # 35

Temporal and Spatial Control of Muscle–Fat Co-Culture in Fibrous Plant Protein Scaffolds for Marbling Cultivated Meat

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The integration of muscle and adipose tissues is essential for reproducing the structure, composition, and sensory characteristics of conventional meat. However, muscle–fat co-culture remains challenging because myogenic and adipogenic cells require distinct biochemical conditions and may mutually inhibit differentiation. This study investigates the spatial and temporal control of bovine muscle and adipose tissue development within three-dimensional fibrous scaffolds fabricated entirely from soy protein isolate and pea protein isolate. Unlike scaffolds incorporating animal-derived biomaterials, synthetic polymers, or non-protein structural binders, these fully plant-protein scaffolds provide an edible, protein-rich architecture that supports cell attachment while contributing directly to the nutritional composition of the final construct. Mold-assisted seeding is used to localize bovine satellite muscle cells within central scaffold regions and bovine preadipocytes within surrounding peripheral regions, creating defined marbling-like patterns without cell-laden bioprinting. Four culture strategies are being compared. In the muscle-first strategy, muscle cells are seeded and differentiated before preadipocytes are introduced and subjected to adipogenic differentiation, followed by a final co-differentiation period. In the adipocyte-first strategy, this sequence is reversed. The remaining strategies involve partial differentiation of both cell types before simultaneous seeding, or simultaneous seeding followed directly by co-differentiation. Quantitative real-time PCR will be used to compare myogenic and adipogenic differentiation among the strategies and identify the sequence that produces the most balanced dual-lineage response. Immunofluorescence and confocal imaging will confirm lineage development and preservation of spatially distinct muscle- and fat-rich regions. This study will establish whether staged differentiation and spatial patterning within edible plant-protein scaffolds can improve the formation of structured, marbling-like cultivated meat.

Abstract # 37

Umami Flavour Enhancement in Cultivated Porcine Muscle Cells by Pulsed Electromagnetic Field Stimulation

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Despite the promise of cultivated meat production as a sustainable source to meet growing global meat demand, replicating the characteristic flavour of conventional in cultivated meat remains a major challenge. This is substantiated by recent studies identifying deficiencies in the abundance of umami-associated flavour metabolites in cultivated meat. In particular, markedly reduced levels of purine nucleotides attributable to the lack of physiological exercise activity were observed in cultivated porcine muscle cells compared with counterparts derived ex vivo from porcine muscle tissue. As key umami-enhancing compounds, purine nucleotides can increase perceived umami intensity by up to 100-fold through synergistic interactions with amino acids in conventional meat. These differences are thought to arise from the absence of post-slaughter biochemical processes that contribute to flavour development in conventional meat. Brief exposures to pulsed electromagnetic field (PEMF) have been shown to stimulate mitochondrial respiration and biogenesis and trigger metabolic adaptations recapitulating the effects of endurance exercise in muscle cells. We therefore hypothesized that exercise-mimicking PEMFs can enhance the production of umami-associated flavour metabolites in porcine muscle satellite cells (pMuSCs). To test this, we evaluated and shortlisted PEMF magnitudes and orientations that enhanced myogenic differentiation and energy metabolism in the cells. Metabolomic profiling revealed that stimulation by specific PEMF configurations led to intracellular accumulation of selected purine nucleotides. Our preliminary findings suggest PEMF application may represent a potential strategy to achieve targeted augmentation of flavour-associated metabolites that improve the sensory quality of animal muscle cells and ultimately cultivated meat.

Abstract # 40

Engineering Marbled Cultivated Meat: A Scaffold-Free Dual-Strategy Platform for Tuneable Bovine Muscle-Fat Composite Constructs

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Replicating the spatial architecture of muscle and intramuscular fat is the key determinant of meat texture and eating quality remains a fundamental bottleneck in structured cultivated meat production. Here we present a scaffold-free, bottom-up platform for fabricating tuneable bovine muscle-fat composites using cell self-assembly in silicone molds[1], [2]. Bovine satellite cells and pre-adipocytes were independently seeded to form discrete muscle and fat cell wires, which were subsequently arranged at defined ratios and fused into macroscopic composite constructs[1]. In parallel, a co-seeding strategy combining satellite cells and pre-adipocytes within the same silicone mold was developed, enabling intrinsic compositional control of muscle-fat ratio at the wire level. Together, these two approaches provide independent spatial and compositional handles on marbling architecture demonstrating proof-of-concept for dual-route tunability of construct composition. Ongoing work is characterising construct viability, lineage identity, and histological similarity to native bovine muscle tissue across both fabrication strategies. This modular cell wire assembly platform offers a flexible, customer-adjustable, and entirely scaffold-free route to structured cultivated beef with defined marbling properties, with direct implications for scalable cultured meat manufacturing.

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Abstract # 41

Scale-up culture of chicken embryo-derived cells using algae extract as a nutrient source

Masanori Wada

ABLE Corpolation

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In cultured meat production, animal cell culture media commonly rely on ingredients derived from grains and microbial fermentation products. As cultivated food production scales up, concerns have been raised regarding competition for grain resources with livestock farming and biofuel production, as well as the associated increase in environmental burden. To address these challenges, we aim to establish the Circular Cell Culture (CCC) system, in which photosynthetic microorganisms serve as an alternative nutrient source for animal cell culture, enabling the continuous supply of nutrients to animal cells as well as the removal and recycling of metabolic waste generated during cultivation.
In this study, the nitrogen-fixing cyanobacterium Trichormus sp. (formerly Anabaena sp.) PCC 7120 was cultivated in a nitrogen-free algal medium. The harvested biomass was hydrolyzed, and the resulting extract was used as a nutrient source for animal cell culture. Vitamins, inorganic salts, and other supplements were added to the extract, and the pH was adjusted to prepare Trichormus Extract Medium (TEM). Chicken embryo-derived cells (DF-1) were cultured in TEM under suspension-agitated conditions. Perfusion culture was subsequently performed using Tangential Flow Filtration (TFF) with a hollow-fiber membrane module while maintaining cell aggregate formation. Finally, the harvested cells were processed into a prototype structured cultivated meat product.
This work demonstrates the potential of cyanobacterial biomass as a sustainable nutrient source for animal cell culture and represents a step toward the development of a resource-circulating platform for cultivated meat production.

Abstract # 44

Designing hybrid cultivated fat–plant protein emulsion-gel sausages for improved textural properties

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Widespread consumer adoption of hybrid plant-based protein and cultivated fat products hinges on replicating the texture, appearance, and likeability of conventional meat products. One important determinant of the functionality and likeability of alternative emulsion sausages is the fat source which may influence emulsion-gel structure, water retention, and textural attributes. This study establishes a framework to determine how diverse fat sources, including cultivated fat, dictate the textural performance of sausage-type emulsion gels in a hybrid product.

Using a Design of Experiments (DoE) approach, the textural properties of sausages are optimised with a fixed fat content and then the fat source is varied in order to study the effect of fat on textural properties. Cultivated fat is evaluated in different ratios with conventional animal and plant fats in order to quantify the impact of these different lipid sources. Product attributes are quantified via Texture Profile Analysis (hardness, cohesiveness, springiness), cooking loss, and microscopy. These response variables map the specific impacts of the formulation and fat source on colour, structure, and functionality elucidating both individual ingredient effects and complex matrix interactions under processing conditions.

This work addresses a key bottleneck in hybrid cultivated/plant-based product development: transforming novel ingredients into products that are not only technically and economically feasible, but also well-liked by consumers. The study generates practical formulation knowledge for future hybrid emulsion gel sausage applications and supports the development of high-quality meat analogues.

Abstract # 45

Safe-by-Design cultured meat production: building a decision support tool to identify and mitigate microbiological and chemical hazards

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Cultured meat production involves multiple inputs that may lack a history of safe use, including novel medium components and scaffolds. Furthermore, scaling up production introduces additional challenges, such as process hygiene, equipment sterilization, environmental contaminants, and human handling. Our aim is to develop a Safe-by-Design decision support tool to assist producers in identifying potential hazards at an early stage of product development and to guide the implementation of preventive and control measures. To achieve this, we systematically identified potential microbiological and chemical hazards, along with their sources, in cultured meat production, through an extensive review of scientific literature, regulatory dossiers, and institutional reports, complemented by expert consultation. Microbiological hazards may be introduced through donor animal, cell lines, equipment, environment, handling during cell harvesting and other ingredients. Reported batch failure rates are highly variable, ranging from 0% to 50% and are mostly due to bacterial contamination. Routine monitoring for microbial contaminants as well as implementing preventive and control measures is therefore essential. The most likely entry routes for chemical hazards are culture medium ingredients and cell structuring materials. The most relevant chemical hazard types identified include antibiotics, allergens, anti-foaming agents, growth factors, and scaffold/microcarrier residues. A key challenge is assessing their safety in the final cultured meat product as regulatory limits are often lacking for many of the components used during production. Preliminary findings on identified hazards and the design and functionality of the Safe-by-Design decision support tool will be presented, together with its application in selected case studies.

Abstract # 48

A hand-built laboratory system for democratisation of cellular agriculture

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Consumer acceptance and transparency remain vital for the cultivated meat industry, however cost, institutional access and specialised knowledge often limit accessibility. This study illustrates how primary cell isolation and culture can occur outside of a conventional laboratory through a user-designed laboratory system based solely on consumer-accessible apparati.

In this investigation, a bespoke positive-pressure glove box was constructed for controlled cell handling, incorporating UV-C sterilisation, HEPA filtration, and an antechamber for material transfer.

Currently, environmental sterility has been tested via assessment of colony-forming units on 9 cm LB agar plates after 1 hour exposure and 48 hours incubation. Results demonstrated minimal microbial growth, averaging 1 CFU (±1) per plate, in comparison to 7.67 (±5.51) and 0 CFU (±0) for positive and negative controls, respectively. Further testing under cell culture-relevant conditions and with optimised procedures is currently being performed to improve results.

Prior to dissemination at ISCCM, cell isolation efficiency from fish adipose and muscle tissue is to be performed to determine the more viable cell type for further iterations of the experiment, with isolation being achieved using publicly available proteolytic reagent alternatives to commercial dissociation enzymes. Isolated cells are cultured above a sous vide on a gelatin substrate, in a novel media formula based on Green Dakara sports drink, whose amino acid and nutrient profiles align with cell culture requirements.

To conclude, this study validates the possibility of cell culture outside a laboratory, serving as a model for further community-based CellAg research.

Abstract # 52

Outcome-driven design thinking for cultivated meat: mapping factors influencing texture, nutrition, and flavour

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Cultivated meat and seafood (CMS) have potential to be part of the future of food production. This novel food producing method comprises the grow of animal cells in bioreactors with the aim of producing products that resemble conventional meat and seafood. To date, there have been many proposals on how to operate the process of cultivating meat and many suggestions on the final product composition. As first of its kind, this work maps the most relevant factors when producing CMS products and presents design thinking approaches on how to produce CMS based on outcomes such as texture, nutritional value, and flavour/aroma.

First, based on literature information and the available CMS companies' dossiers, we fabricated our design on how the CMS production process would look like and how the biomass produced is going to be incorporated in the final products. Then, we fabricated our own models on how changes on the type of biomass and percentage of biomass will impact the final product nutritional value, texture, and aroma/flavour. Different models were fabricated for the development of structured and unstructured products. The interpretation of each model was performed leading to clear conclusions on how different cell types and cell percentage categories (e.g., Category > 90%, Category 30-90%, Category 10 to 30% cells, Category 1 to 10 %, Category < 1 % cells) will impact the final product organoleptic features.

Finally, all CMS products with full regulatory authorization were listed and mapped onto the fabricated models. Ultimately this work aims to build a framework for product development in CMS.

Abstract # 57

The hidden impact of process components on cultivated fat production

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As cultivated meat and fat production move towards larger-scale and food-grade bioprocesses, the materials surrounding cells need to be evaluated beyond the culture medium formulation alone. Mammalian cell culture systems often rely on additives and process equipment originally developed for pharmaceutical manufacturing, but their compatibility with cells used for cultivated fat production is poorly understood.
This study investigates the impact of two types of non-media process components on porcine mesenchymal stem cells: intentionally added food-grade antifoams and unintentionally introduced process equipment-related leachables (PERLs) from single-use systems.
First, a panel of food-grade antifoam candidates was screened as potential replacements for conventional foam-control additives. Candidates were evaluated for effects on cell viability, adhesion, spheroid formation, adipogenic differentiation, and foam suppression. Selected top formulations showed robust biocompatibility and effective foam control, supporting their suitability as food-compatible process additives. In parallel, three model leachables and two single-use system extracts were assessed as potential exposure risks from process equipment. Cytotoxicity assays and adipogenic differentiation showed that selected leachables negatively affected porcine cell performance.
Together, this study highlights that process materials should not be treated as neutral elements of cultivated fat production. Food-grade antifoams may be used as functional replacements for conventional additives, while PERLs require a careful safety assessment using readouts relevant to cultivated fat production. This work supports a material-conscious approach to designing scalable and food-compatible cell culture systems.

Abstract # 59

FEASTS project: Overview and outcomes

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This presentation reports key findings of the EU project “FEASTS - Cultured Meat and Seafood (CM/CSF) in a Sustainable, Resilient and Fair European Food System”. Additionally, teaching experiences of Cellular Agriculture in Portugal, will be briefly summarized.
FEASTS is a collaborative research programme delivering comprehensive, multidisciplinary knowledge base about CM/CSF, and their place in the food system. With the ultimate ambition of providing a decision support tool for decision-making on European and national policies, FEASTS benchmarks and develops sustainable novel key enabling technologies, establishes a stewardship model for the sector; providing a comprehensive assessment of its multidimensional impact and guidance for policy and regulatory frameworks. After three years of research, insights on the technological platforms needed for cultured meat production, key performing indicators, technological mapping, potential technological trajectories, product types, and business model positioning are presented. An overview on drivers and barriers of consumer acceptance of CM/CSF and consumer segmentation based on surveys is discussed. A methodology for mapping the different stakeholders was introduced to support co-creation actions, assess societal impacts, and provided recommendations for responsible innovation. Different scenario of centralization and decentralization are discussed, both from the bioreactors and bioprocesses development perspective, but also from the impact on society. Key suggested recommendations for the sector are discussed. Research advances and prospective work in cultivated meat and seafood is briefly presented, with focus on food structuring using scaffoldings and 3D Bioprinting. Finally, it is shared the teaching methodology and experience of a novel educational initiative, a new course in cellular agriculture, launched in the spring term of the 2025/2026 academic year at the Department of Bioengineering of IST.

Abstract # 60

Defining Key Performance Indicators for the cultured meat industry: establishing expert-informed metrics to measure technological performance in cellular agriculture.

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Key Performance Indicators (KPIs) are fundamental tools for companies that can be used to measure organizational performance upon a defined set of objectives. Along with Key Risk Indicators, KPIs can aid in monitoring and managing organizational and industrial performance of a given technology. As any nascent industry, cultured meat (CM) production still lacks publications about KPI frameworks that can guide early-stage entrants into evaluating their technologies and applications in industrial CM manufacturing.

Through a blend of literature analysis, expert interviews and expert validations, this work describes a comprehensive framework of both quantitative and qualitative KPIs for the different steps of the CM production process, from technological and process KPIs in cell line and media development to those pertaining to nutrition and environment. Whenever possible, values as general guides are provided for each KPI according to different Technology Readiness Levels (TRLs), split into three groups: Lab-Scale (TRLs 1-3), Pilot Scale (TRLs 4-6) and Commercial (TRLs 7-9).

The KPI framework developed here highlights both literature and technology gaps that should be addressed by collective research and funding schemes, including those that would improve the robustness of the sector. It also describes literature and commercial discrepancies between standards for the different technological inputs of the CM process, including cell lines, culture media, scaffolds and bioreactors. This KPI framework can inform investors, regulatory and funding bodies, as well as start-ups and researchers wanting to benchmark their technologies against the expected performance in CM manufacturing.

Abstract # 68

A novel byproduct ingredient as a medium supplement for cultivated meat production

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The development of cheaper and more sustainable culture media is an essential objective in achieving large-scale production of cultivated meat (CM). Conventionally, culture media are supplemented with foetal bovine serum (FBS), which provides essential growth factors and nutrients for cell proliferation. However, due to ethical, sustainability, and economic concerns, there is considerable interest in finding serum alternatives. Protein hydrolysates have emerged as promising complementary sources of amino acids, lipids, and vitamins. The aim of this study was to test a novel hydrolysate ingredient (NHI) as supplement to or replacement of serum for culture of bovine satellite cells (BSCs). The hydrolysate was assessed for cytotoxicity and its effect on cell proliferation in cultured BSCs via MTT assays and short-growth analysis. A range of NHI concentrations (0.2, 0.5, 1, 2, 2.5, and 5%) were tested in serum-free and serum-reduced (1, 2.5, 5, and 10% FBS) conditions. Concentrations of NHI higher than 0.5% were cytotoxic to the satellite cells. Supplementation with 0.2% and 0.5% hydrolysate enhanced cell viability in serum-free conditions, and at 2.5%, 5%, and 10% FBS were not significantly different from the standard growth medium control. Furthermore, the 0.2% concentration showed the potential to support cell growth in low-serum (2.5% FBS) medium and maintain cell morphology similar to the 20% serum containing medium. Further investigation is required to test the NHI as a media supplement for long-term culture of BSCs. Nevertheless, this work demonstrated the potential of a novel plant hydrolysate as a cost-effective supplement for BSCs culture medium for CM production.

Abstract # 70

Cell-Derived Extracellular Matrix Supports Scaffold-Free Tissue Organisation and Facilitates Scalable Spheroid Culture of Bovine Satellite Cells

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Scaling up cell culture of muscle cell precursors and stem cells is a major challenge for biomanufacturing using current tissue culture approaches. Whilst methods such as micromass culture (high-density cell droplets) and pellet culture (centrifugation as means to facilitate cell aggregation) have routinely been used in tissue engineering of musculoskeletal tissues, they require high cell numbers and often result in cellular differentiation. This study investigates how immortalised bovine satellite cells (iBSC) in low concentration cell suspension produce and organise ECM to support scaffold-free aggregate formation for applications in the cultivated meat industry.

iBSCs were cultured in round-bottom low-attachment plates in low-serum conditions, and the effect of ascorbic acid on collagen production and aggregate formation was explored. Aggregates were monitored using metabolic activity assays and assessed using imaging and histological analysis. Proliferation and live/dead cell ratios of the aggregates after 3 days of culture were compared to the proliferation rates seen on the routinely used 2D tissue culture plastic.

We show that under reduced-serum conditions, the cells formed structurally robust and viable spheroids, demonstrating an increase in collagen production and maintained metabolic activity throughout the incubation period. As a robustness test, the aggregates were transferred to a bioreactor model to assess the model's scalability, in which they retained structural stability under agitated suspension, offering a practical strategy for scalable production of muscle precursors, bypassing the cost and complexity of synthetic scaffolds, microcarriers and complex bioreactors.

Abstract # 81

Making healthier animal fat through genetic engineering

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We have developed an immortalised fat progenitor cell line from pig with unprecedented capacity to produce fat in vitro. By overexpression of key enzymes in the omega-3 biosynthesis pathway, we have developed an in-vitro system of generating fat with high levels of beneficial polyunsaturated omega-3 fatty acids. We now seek to generate minimally genetically edited cells with tailored fat composition for food manufacture applications

Abstract # 84

Interfacial Engineering Decouples Cell-Adhesive Function from Bulk Formulation in Edible Polysaccharide Microcarriers

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Scalable cultivated meat production requires edible, animal-free microcarriers that support robust cell adhesion and proliferation under cost-effective culture conditions. However, many existing scaffold designs address this surface-level biological requirement through material-specific bulk formulations rather than broadly adaptable interface engineering strategies. Herein, we report a post-fabrication interfacial modification strategy that converts negatively charged edible polysaccharide microcarriers into cell-supportive microenvironments without incorporating animal-derived or protein-based components into the initial scaffold-forming matrix. Preformed alginate and carrageenan microcarriers were modified with tannic acid and poly-L-lysine using a layer-by-layer approach. This modification altered surface physicochemical properties and promoted the adsorption of serum proteins, including integrin-interacting adhesion proteins, onto the microcarrier surface. In line with established integrin-mediated adhesion frameworks, muscle cells exhibited improved initial attachment efficiency and sustained proliferation on modified microcarriers compared with unmodified polysaccharide controls. By localizing the design intervention to the cell-facing interface, this strategy reduces the need to reformulate the scaffold bulk to achieve cell-adhesive functionality. More broadly, this work establishes a design framework for engineering edible microcarriers across diverse polysaccharide systems by decoupling cell-adhesive surface functionality from bulk food-material formulation, thereby preserving flexibility in scaffold material selection for cultivated meat applications.

Abstract # 86

Scalable, Serum-free Expansion of Bovine Pre-Adipocytes for Cultivated Meat Production

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Cultivated fat holds significant promise for enhancing the sensory and nutritional properties of cultivated meat products. A key challenge in this field is the efficient expansion of adipogenic precursor cells. In this study, we present two scale-up strategies: single-cell suspension culture (1) and microcarrier cell culture (2).

(1) Bovine pre-adipocytes were successfully isolated and adapted to single-cell suspension culture in serum-free media under agitated conditions. Robust cell growth was achieved in Erlenmeyer flasks and optimization of culture conditions in orbitally shaken bioreactors is currently underway.

(2) As most mammalian cells are not adaptable to suspension culture, we developed in-house microcarriers (MCs) using cost-efficient materials commonly used in the food industry. The MCs provide fast cell attachment and robust cell growth under serum-free conditions in both spinner flasks and stirred-tank bioreactors. The MCs are dissolvable, facilitating downstream cell harvesting, and enable bead-to-bead transfer, providing an easy scale-up process. The MCs support the growth of other relevant cell types, such as skeletal muscle satellite cells and mesenchymal stem cells, highlighting their potential for multiple lineages.

Together, these findings demonstrate two scale-up approaches with promising results for the expansion of bovine pre-adipocytes for cultivated meat applications.

Abstract # 87

ESTABLISHMENT OF A BIOSAFE PORCINE SUSPENSION CELL LINE AND LARGE-SCALE CONTINUOUS MANUFACTURING FOR CULTURED PORK

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Global pork demand keeps growing, yet traditional pig farming faces massive resource pressure and environmental challenges. Cell-cultured pork represents a sustainable substitute, though its industrial rollout is hindered by bottlenecks such as anchorage dependence, limited cell proliferation, expensive culture media and immature large-scale production platforms.
This research spontaneously immortalized primary porcine muscle cells through prolonged serum-free suspension domestication, obtaining a stable cell line capable of single-cell suspension growth with a consistent doubling time of 24±2 h. Single-cell transcriptomics uncovered profound cell fate reprogramming in the immortalization process: muscle stem cells experienced lineage conversion and gradually became adipocyte progenitor-like cells. The team built qualified master and working cell banks with comprehensive biosafety assessments.
Performance comparisons among fed-batch, perfusion and continuous cultivation showed continuous culture delivered optimal medium efficiency. The study proposed an innovative FCR indicator tailored for cultured meat, attaining an outstanding 0.63:1 FCR in a 2000 L bioreactor, far superior to the 2.8:1 ratio of conventional pig production. After 22 days of continuous culture, 97.18 kg nutritionally stable cell biomass was harvested. Economic modelling proved medium optimization can drive cost competitiveness.
This work develops a non-GMO, biosafe porcine suspension cell line and verifies merits of large-scale continuous manufacturing, laying solid technical foundations for industrialized sustainable cell-cultured pork.

Abstract # 89

Life Cycle Assessment of Cultivated and Conventional Meat Production Systems

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Rising global food demand and the environmental impacts of conventional meat production have increased interest in alternative protein sources. Cultivated meat has emerged as a promising technology with the potential to reduce greenhouse gas (GHG) emissions and land use while supporting food security. This study aims to quantify and compare the environmental impacts of conventional and cultivated meat production using Life Cycle Assessment (LCA) to identify environmental hotspots and opportunities for improvement.

A cradle-to-gate system boundary was applied to both production systems, with a functional unit of 1 kg of protein to enable direct comparison. Life cycle inventory data were compiled from literature sources and primary laboratory data. Conventional meat inventories include feed crops, fertilizers, and on-farm energy consumption, while cultivated meat inventories include cell culture media components, growth factors, and electricity requirements. The analysis focuses on the Canadian context while incorporating global datasets where necessary. Environmental impacts will be assessed in openLCA using the ReCiPe 2016 v1.03 Midpoint (E) life cycle impact assessment (LCIA) method.

Previous studies suggest cultivated meat may reduce GHG emissions and land use compared with conventional meat production but may require higher energy inputs. However, significant uncertainties remain due to limited Canadian-specific data and data gaps associated with emerging cultivated meat technologies. Ongoing work involves addressing these gaps, modelling the inventories in openLCA, conducting LCIA, and performing hotspot analyses. The findings will contribute to evaluating the sustainability of cultivated meat and informing future food production strategies.

Abstract # 91

Genotoxicity Assessment of the Cultivated Pork Product Using Complementary In Vitro and In Vivo Assays

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Genotoxicity assessment is an important component of cultivated meat safety evaluation. We evaluated the genotoxic potential of the cultivated pork product (PM1-MA-01) using complementary in vitro and in vivo genotoxicity assays under the OECD Principles of Good Laboratory Practice (GLP). Genotoxicity was assessed using an in vitro bacterial reverse mutation (Ames) assay according to OECD TG 471, together with in vivo bone marrow micronucleus and liver comet assays conducted according to OECD TG 474 and 489, respectively. The in vivo assays were incorporated into a 13-week repeated-dose oral toxicity study in Sprague-Dawley rats. PM1-MA-01 produced no mutagenic response in five bacterial strains at concentrations up to 3,000 μg/plate, with or without metabolic activation. Following repeated oral administration at doses up to 2,000 mg/kg/day, micronucleated polychromatic erythrocyte frequencies ranged from 5.4 to 8.4 per 4,000 polychromatic erythrocytes, compared with 6.2 in vehicle controls, with no statistically significant increase. Liver % tail DNA ranged from 0.19 to 0.23%, compared with 0.37% in vehicle controls, also without a statistically significant increase. Positive controls produced significant responses in both in vivo assays ($P<0.01$), confirming assay responsiveness. Taken together, the absence of mutagenic activity and the lack of treatment-related increases in micronucleus formation or DNA strand breaks indicate that no genotoxic potential was identified under the conditions of this study. These findings provide complementary safety evidence for the toxicological characterization of cultivated pork product.
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Abstract # 92

Development and Validation of an LC-MS/MS Method for the Quantitative Determination of a Cultivated Pork Product in Dose Formulations for GLP Nonclinical Studies

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Cultivated meat refers to food products produced by culturing animal cells in vitro and processing the resulting biomass into food for human consumption. It has attracted attention as a potential alternative to conventional livestock farming due to its potential benefits for climate change, food security, environmental sustainability, and animal welfare. However, robust scientific evidence is needed to establish its safety.
For novel foods such as cultivated pork products, Good Laboratory Practice (GLP) nonclinical toxicity studies are essential for safety assessment. Accurate determination of the concentration, homogeneity, and stability of dose formulations is critical to ensure study reliability. Therefore, this study aimed to develop and validate an LC-MS/MS method for the quantitative determination of the cultivated pork product (PM1-MA-01) in dose formulations.
L-Glutamic acid, a major amino acid in the test article, was selected as a surrogate marker for quantification. Protein precipitation using perchloric acid was applied to extract amino acids, and HILIC-MS/MS using an amide column was employed to achieve high selectivity and sensitivity. The developed method was validated in accordance with the ICH Q2(R2) guideline for system suitability, specificity, linearity, lower limit of quantification, accuracy, precision, homogeneity, stability, re-injection reproducibility, and carry-over. The validated method was successfully applied to determine the concentration and homogeneity of dose formulations. This approach is expected to provide reliable analytical data for evaluating dose formulation quality and support the safety assessment of cultivated pork products in future nonclinical studies.
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