Good Food Institute APAC

State of the industry and science of alternative proteins

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Science and Technology Manager, GFI APAC

NSTDA Annual Conference: NAC2023, 29 March 2023

Good Food Institute APAC

Agenda

1. **GFI introduction**
2. The Science: Three pillars of alternative proteins
3. Plant-based meat (PBM)
4. Fermentation-derived (FD) proteins/ingredients
5. Cultivated meat (CM)
6. What the future holds

Good Food Institute

GFI is an **international network of nonprofit think tanks** developing the roadmap for a sustainable, secure, and just protein supply.

*We are a **force multiplier**, bringing the expertise of our 180+ staff across our six regions to the rest of the world*

Our work spans three areas:

Science and Tech
Advance foundational, open-access research across alternative proteins

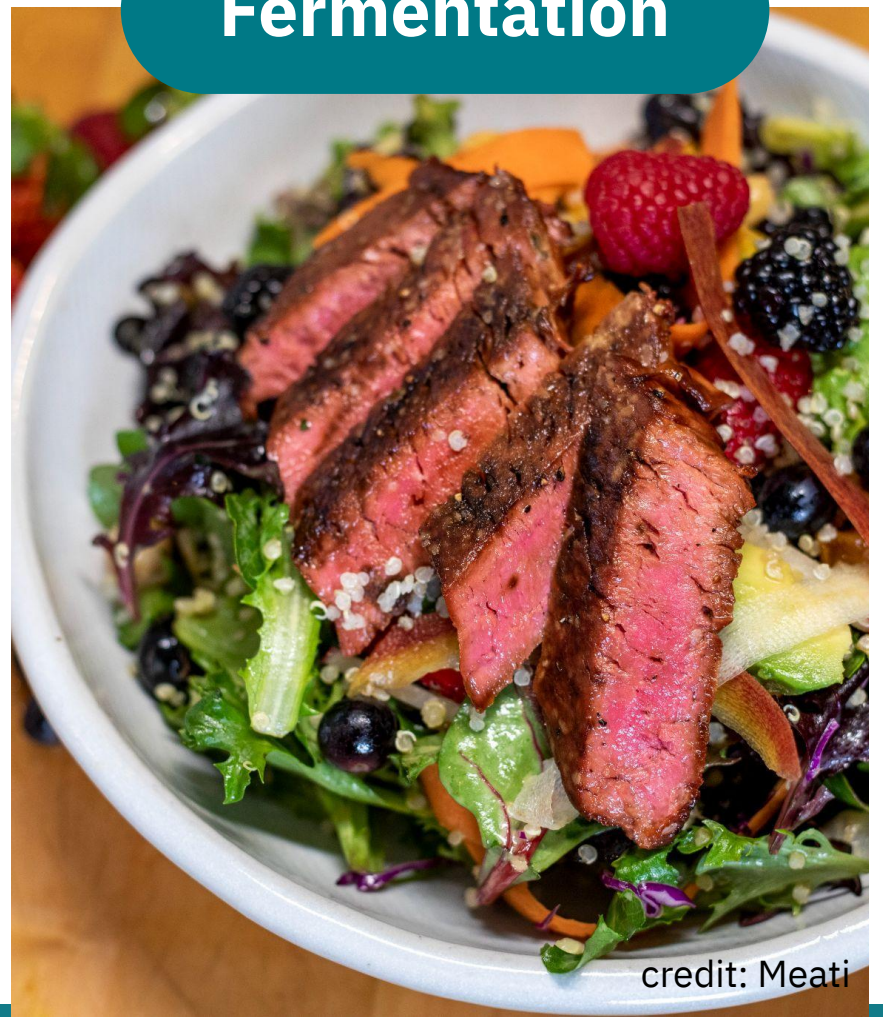
Corporate Engagement
Partner with companies and investors to unlock funds, innovation, and scale

Policy
Work with policy actors to secure support for R&D and ensure regulatory clarity

Protein diversification

Plant-based

Fermentation



Cultivated

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Production value chain: Plant-based meat (PBM)

CROP SELECTION

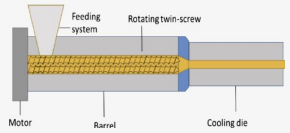
The best source material for the end product is selected

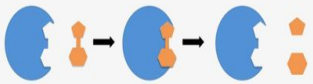
CROP OPTIMISATION

Crops are optimised via breeding or engineering

INGREDIENT OPTIMISATION

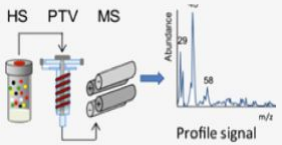
Raw materials are isolated and functionalised by mechanical and chemical processes to create optimal ingredients for the end product



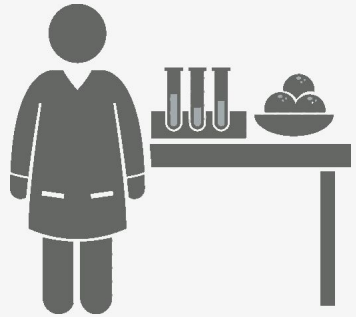


END PRODUCT COMPOSITION AND PROCESS OPTIMISATION

The correct mixs of ingredients and processes are established to create the desired taste, texture, smell, and structure



Final product



Fermentation applications in alternative proteins

TRADITIONAL FERMENTATION

- Uses **intact live microorganisms** to modulate and process plant-derived ingredients.
- Produces unique flavour and nutritional profiles, modified texture.

BIOMASS FERMENTATION

- Leverages microorganism **fast growth** and **high protein content** to produce large protein quantities.
- Biomass serves as predominant or primary ingredient of a food product.

PRECISION FERMENTATION

- Uses **microbial hosts** to produce **specific functional ingredients** that often require greater purity.
- Ingredients enable improved sensory characteristics, functional attributes.

Production value chain: Fermentation-derived (FD) ingredients

FEEDSTOCK OPTIMISATION

Any source of biomass can theoretically serve as a feedstock for fermentation-based protein production.

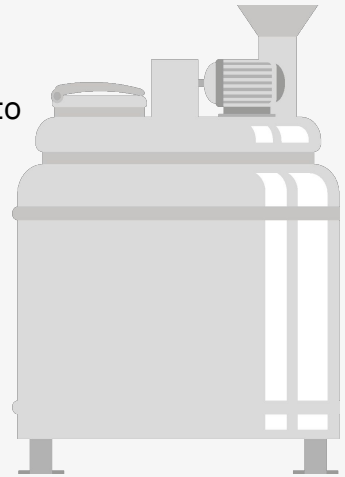
STRAIN DEVELOPMENT & TARGET SELECTION

The cells are optimised for production of the desired target molecule of interest via selection and/or engineering.

BIOPROCESS DESIGN

The cells are added to a bioreactor along with cell culture media containing the feedstocks.

The conditions inside the bioreactor allow the cells to proliferate and, if applicable, accumulate their target molecules.

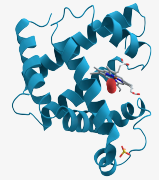


FINAL PRODUCT FORMULATION AND MANUFACTURING

The whole cell biomass or fractions thereof can be harvested to produce a ingredients for alternative meat, egg, or dairy production.

Whole biomass

Alternatively, a specific target expressed by the cells can be isolated and purified for use as a high-value functional ingredient.

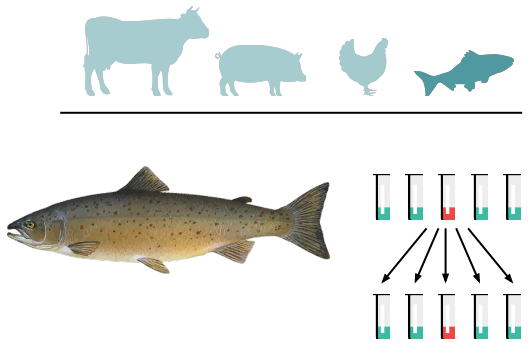


Functional ingredient

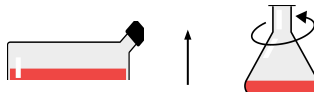
Production value chain: Cultivated meat (CM)

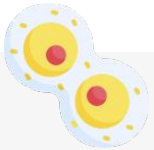
SAMPLING

A small sample of cells is obtained from an animal.



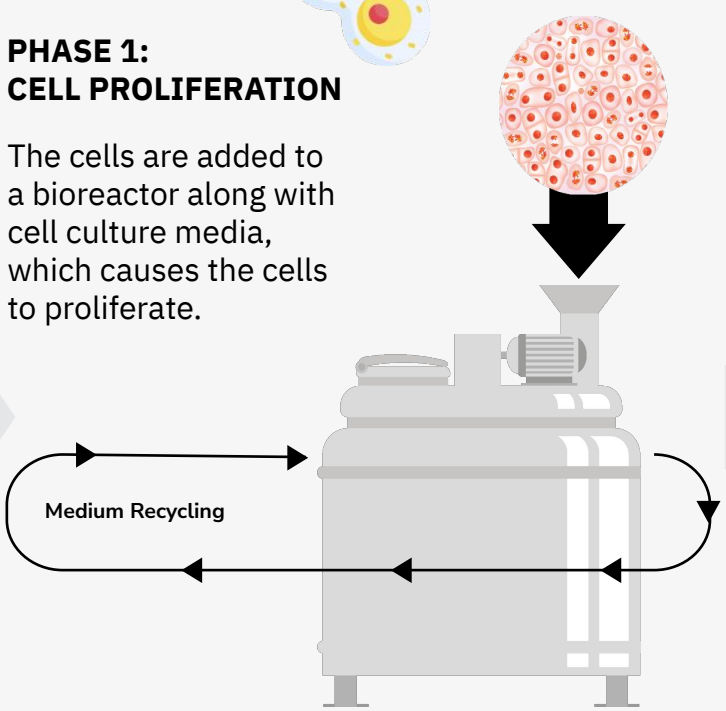
CELL STARTER CULTURE

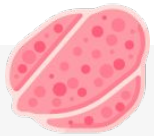




PHASE 1: CELL PROLIFERATION

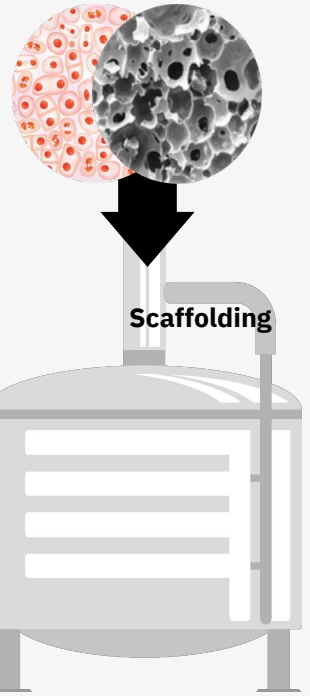
The cells are added to a bioreactor along with cell culture media, which causes the cells to proliferate.





PHASE 2: TISSUE MATURATION

A change in culture conditions pushes the cells to differentiate into muscle, fat, and connective tissue.



Final product

CELLS AT MATURATION
Primarily muscle, fat, and connective tissue.

Fat cell

Muscle cell

Fibroblast cell

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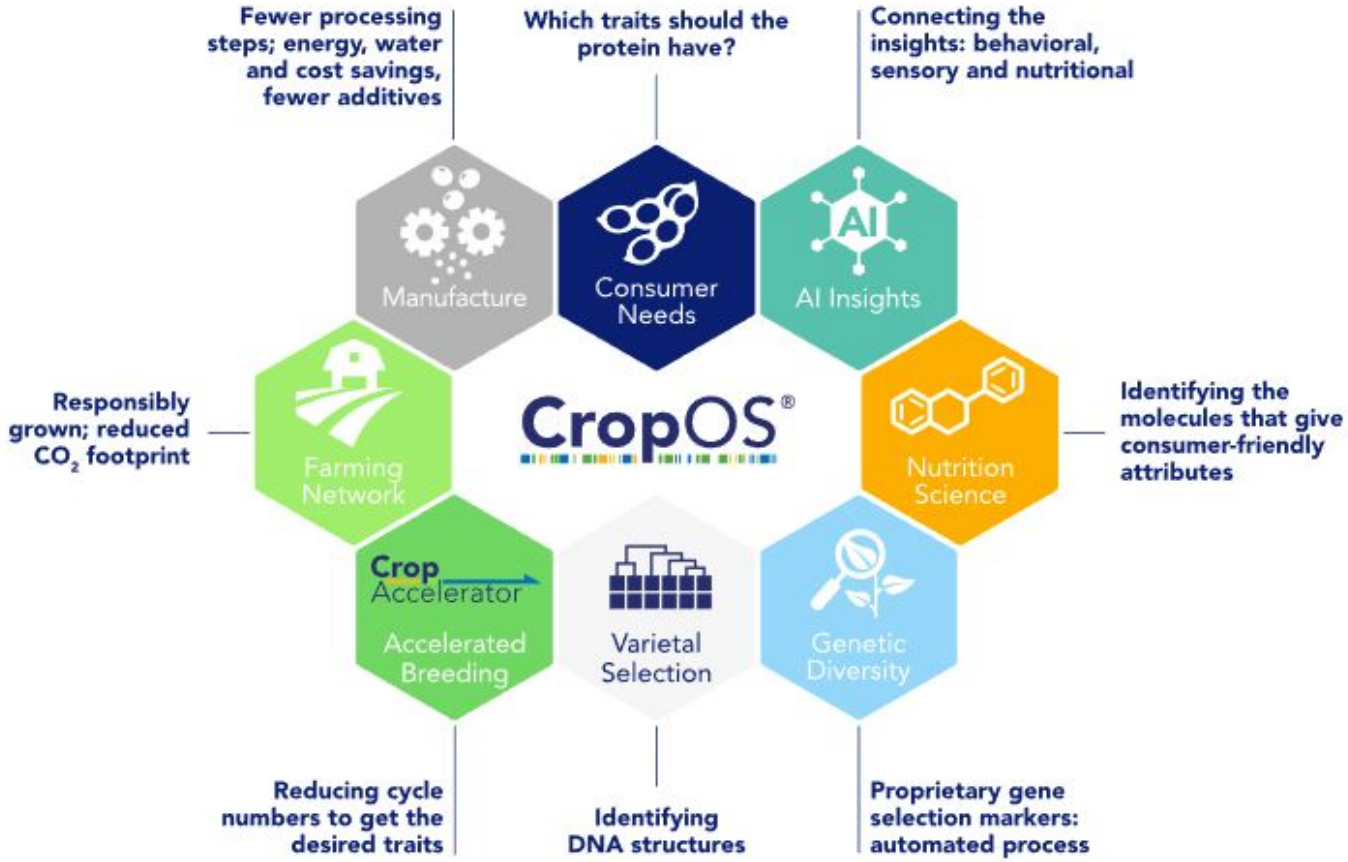
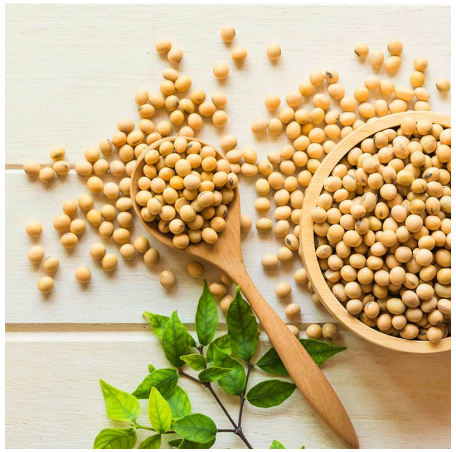
Benson Hill crop breeding technologies





70% less water

50% less CO_2 emission

Benson Hill partnerships with Kelloggs & ADM

ADM®

Scaling up ultra-high protein soybeans

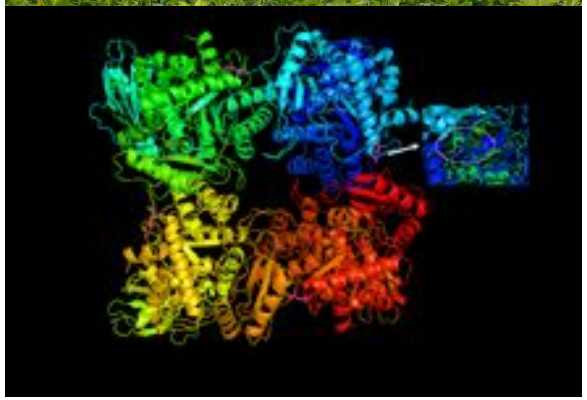
BENSON HILL®

Kellogg's®

MorningStar FARMS®

Expansion of raw materials for plant-based meat

leaft FOODS



Burcon

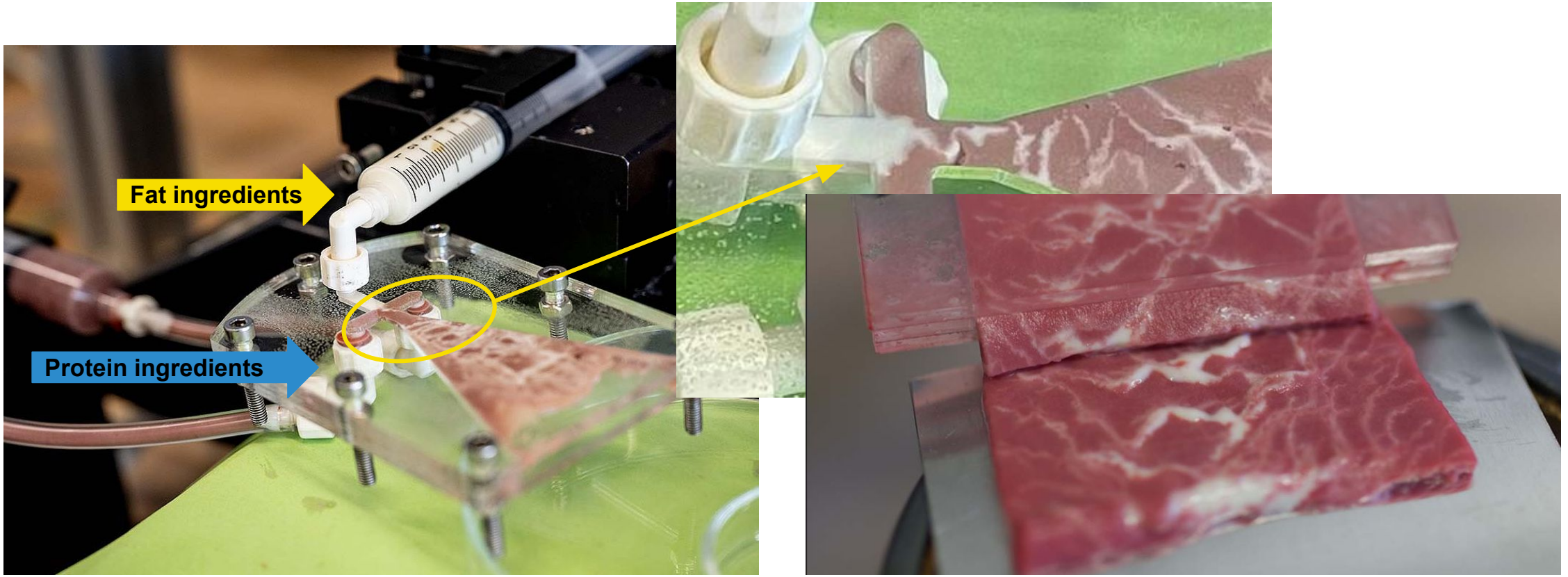
apparo

EQUINOM

ROQUETTE

Offering the best of nature™

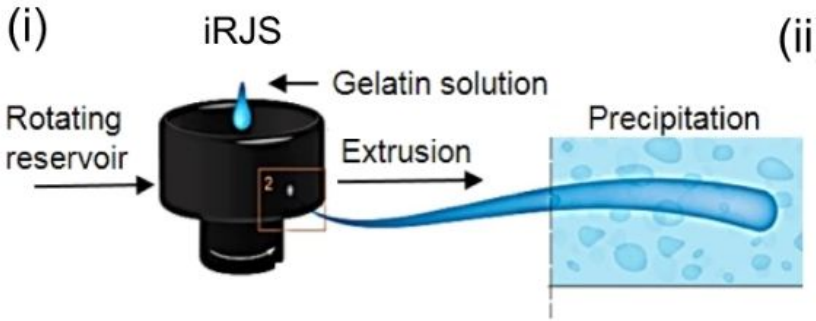
Novel innovation for PBM productions



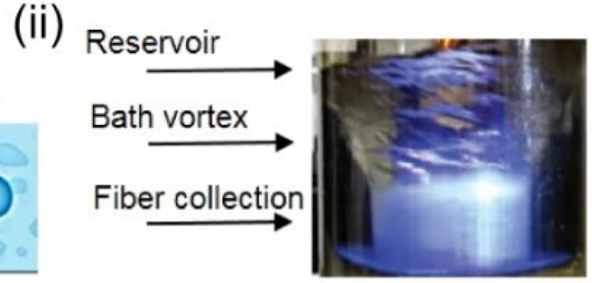
Alternative texturisation technologies

NOVA MEAT

(immersion rotary jet spinning)



Tender



credits: Tenderfood, NovaMeat

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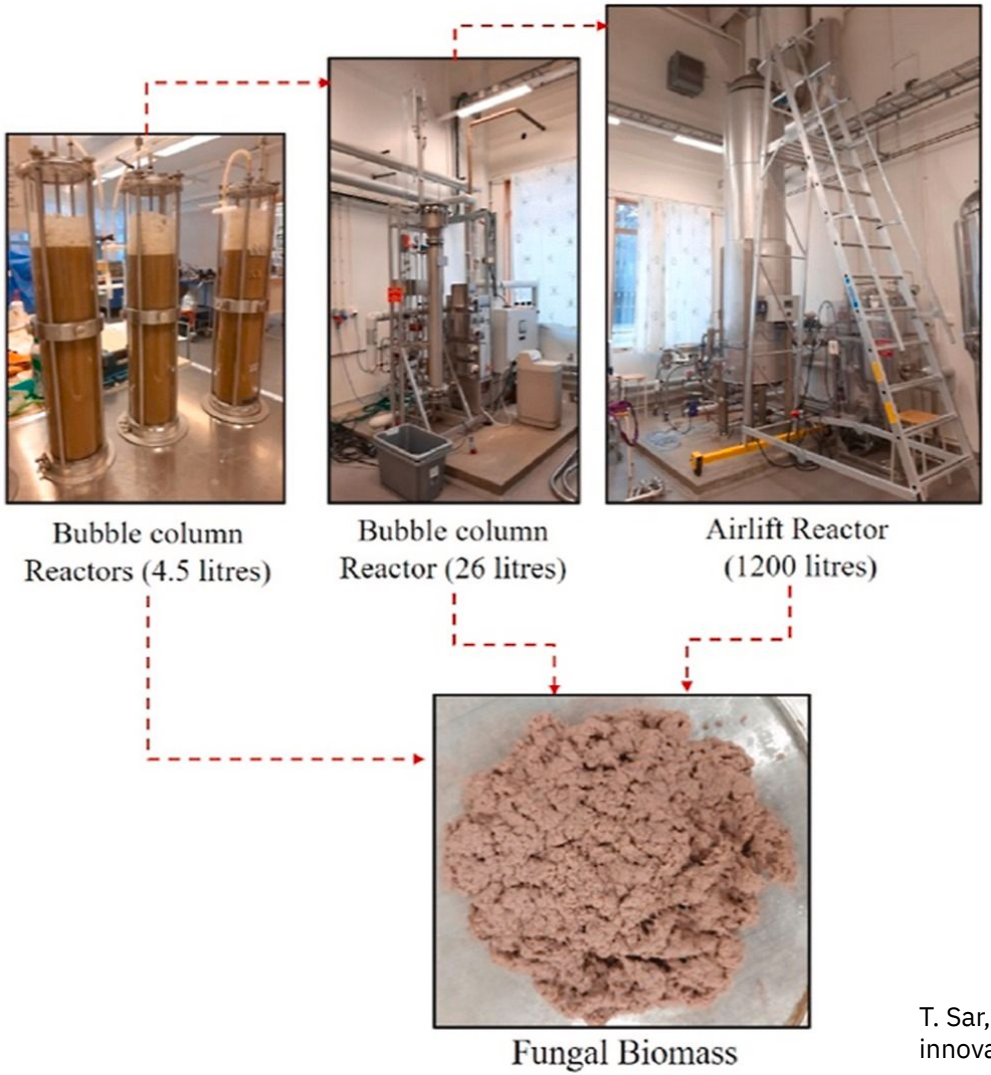
Feedstock optimisation from bench to pilot scale



ELSEVIER

Food Bioscience
Volume 47, June 2022, 101637

Demo-scale production of protein-rich fungal biomass from potato protein liquor for use as innovative food and feed products

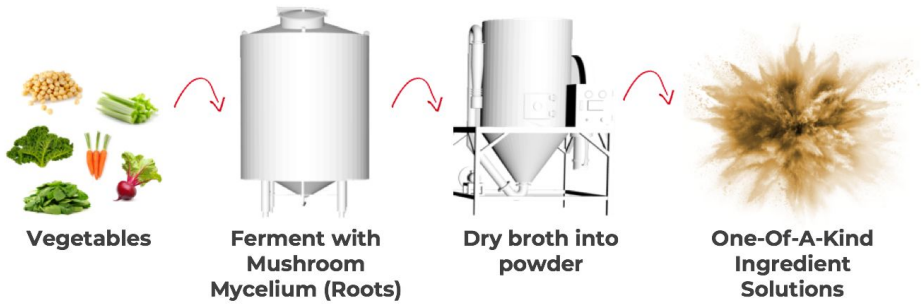
Taner Sar [a], Karin Larsson [b], Rikard Fristedt [b], Ingrid Undeland [b], Mohammad J. Taherzadeh [a]

T. Sar, et al.Demo-scale production of protein-rich fungal biomass from potato protein liquor for use as innovative food and feed products, Food Bioscience, Volume 47, 2022, 101637, ISSN 2212-4292,

Novel feedstocks for microbial protein production

Upcycling food waste

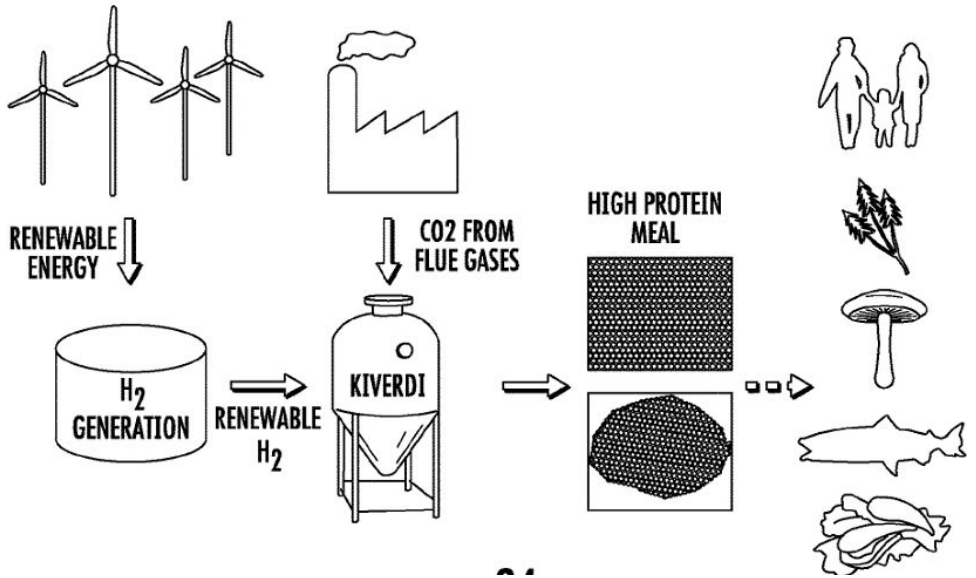
MYCO TECHNOLOGY™



Gas fermentation

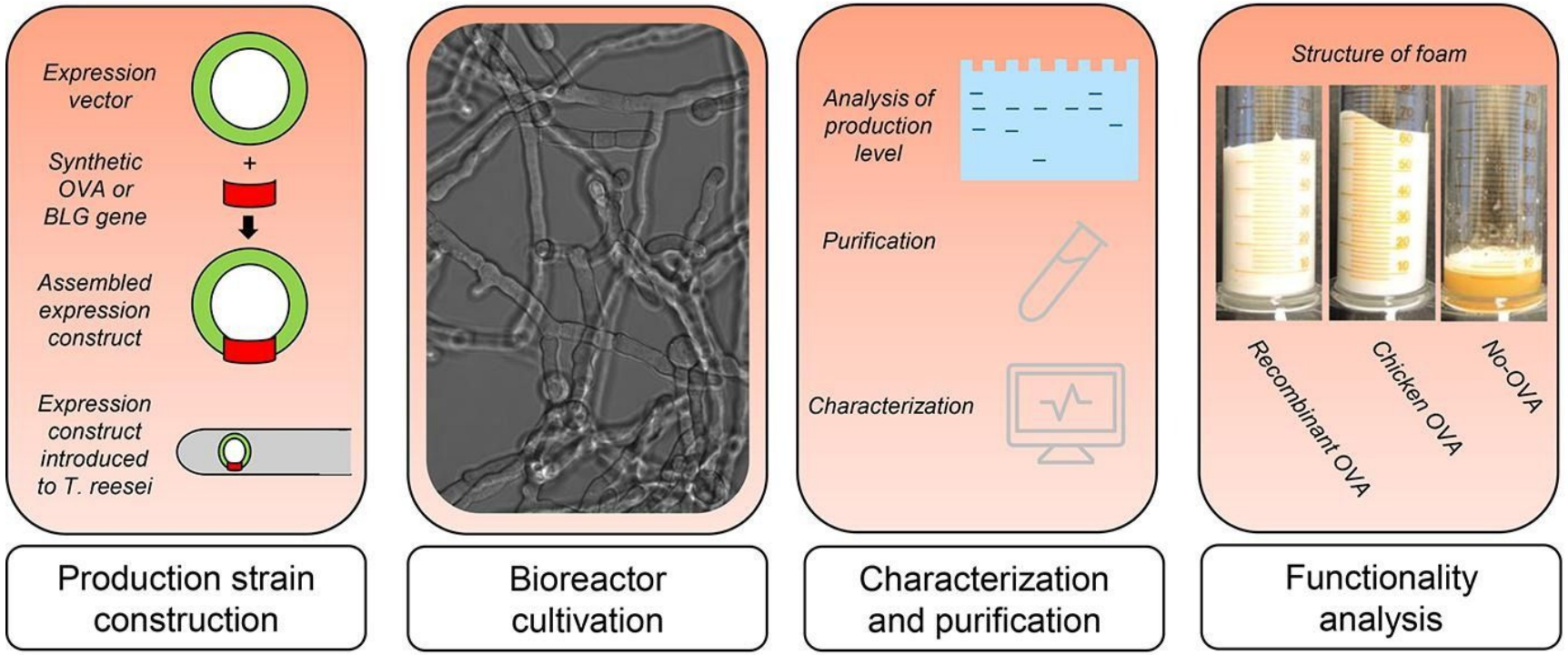
air protein

KIVERDI



Product development in precision fermentation

Production of bovine beta-lactoglobulin (BLG) and hen egg ovalbumin (OVA) by *Trichoderma reesei* using precision fermentation technology and testing of their techno-functional properties



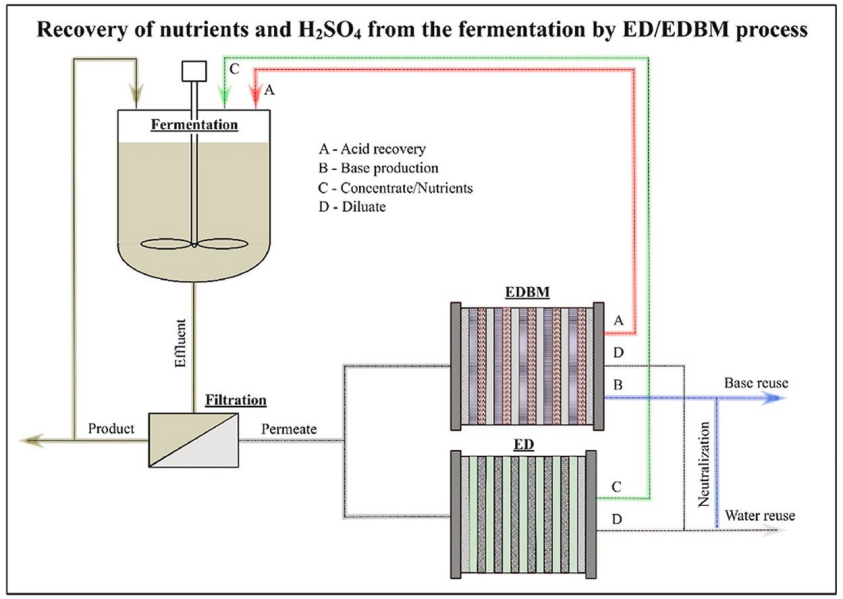
VTT Tr-BLG and Tr-OVA:https://doi.org/10.1016/j.foodres.2022.112131; VTT Tr-BLG LCA: https://doi.org/10.1007/s11367-022-02087-0

Bioprocess developments for medium recycling

Journal of Cleaner Production
Volume 377, 1 December 2022, 134436

Circular production – Evaluation of membrane technologies for nutrient recycling from a microbial fermentation effluent

Katarina Knežević [a], Kerstin Rastädter [b], Julian Quehenberger [b], Oliver Spadiut [b], Jörg Krampe [a], Norbert Kreuzinger [a]

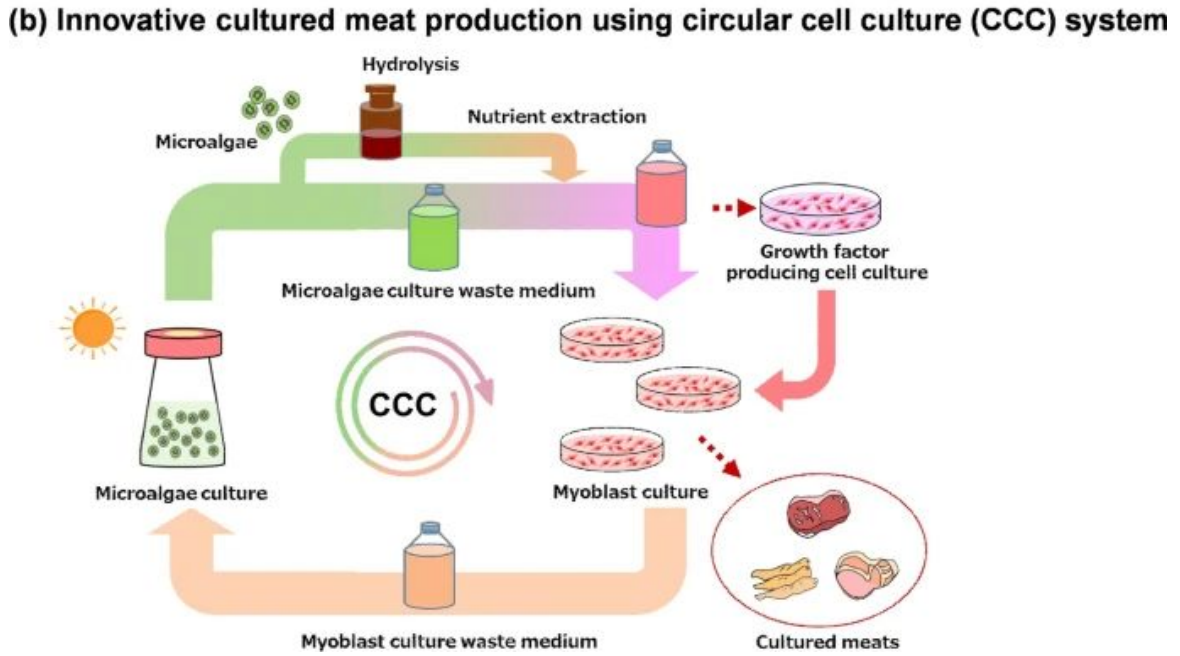


Original Paper | Published: 12 September 2022

A circular cell culture system using microalgae and mammalian myoblasts for the production of sustainable cultured meat

Yuji Haraguchi, Yuta Okamoto & Tatsuya Shimizu

Archives of Microbiology **204**, Article number: 615 (2022) | Cite this article



https://doi.org/10.1016/j.jclepro.2022.134436; https://doi.org/10.1007/s00203-022-03234-9

Precision fermentation products enabling other pillars of alternative proteins

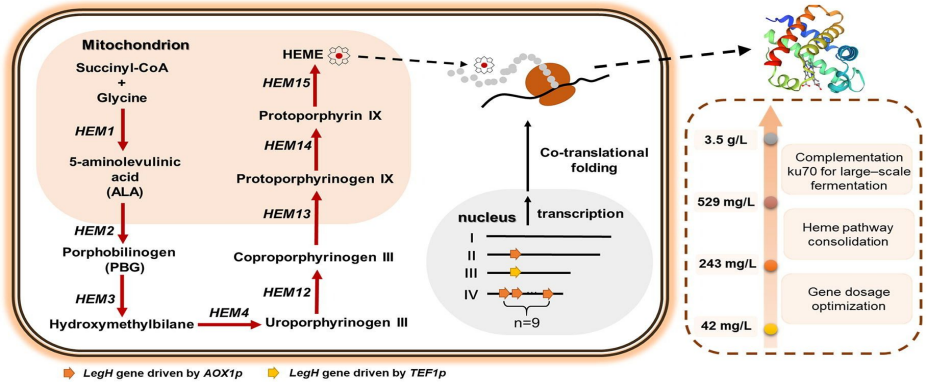
Precision fermentation **heme proteins**

ELSEVIER

Bioresource Technology
Volume 363, November 2022, 127884

High-level secretory production of leghemoglobin in *Pichia pastoris* through enhanced globin expression and heme biosynthesis

Youran Shao [a, b], Changlu Xue [c], Wenqian Liu [a, b], Siqi Zuo [a, b], Peilian Wei [c], Lei Huang [a, b], Jiazhang Lian [a, b, d], Zhinan Xu [a, b]



KU LEUVEN paleo

Foods. 2022 Jul; 11(13): 1985.
Published online 2022 Jul 5. doi: 10.3390/foods11131985
PMCID: PMC9265346
PMID: 35804800

Improving the Aromatic Profile of Plant-Based Meat Alternatives: Effect of Myoglobin Addition on Volatiles

Jolien Devaere,[1] Ann De Winne,[1] Lore Dewulf,[1] Ilse Fraeye,[1] Irena Šoljić,[2] Elsa Lauwers,[2] Andy de Jong,[3] and Hermes Sanctorum[3,*]

IMPOSSIBLE™

Mutated AOX1 promoter for improved expression and/or expression without methanol

(19) **United States**
(12) **Patent Application Publication**
Hoyt et al.
(10) **Pub. No.: US 2020/0332267 A1**
(43) **Pub. Date: Oct. 22, 2020**

(54) **MATERIALS AND METHODS FOR PROTEIN PRODUCTION**

(71) Applicant: **Impossible Foods Inc.**, Redwood City, CA (US)

Publication Classification

(51) **Int. Cl.**
C12N 9/04 (2006.01)
C12N 15/10 (2006.01)

(52) **U.S. Cl.**

Granted 08/30/2022

WO 2022/221407
PCT/US2022/024616

Kyomei
Next Generation Meat Proteins

TRANSGENIC PLANTS COMPRISING MYOGLOBIN AND METHODS FOR PRODUCING MYOGLOBIN IN TRANSGENIC PLANTS

https://doi.org/10.1016/j.biortech.2022.127884, https://doi.org/10.3390/foods11131985

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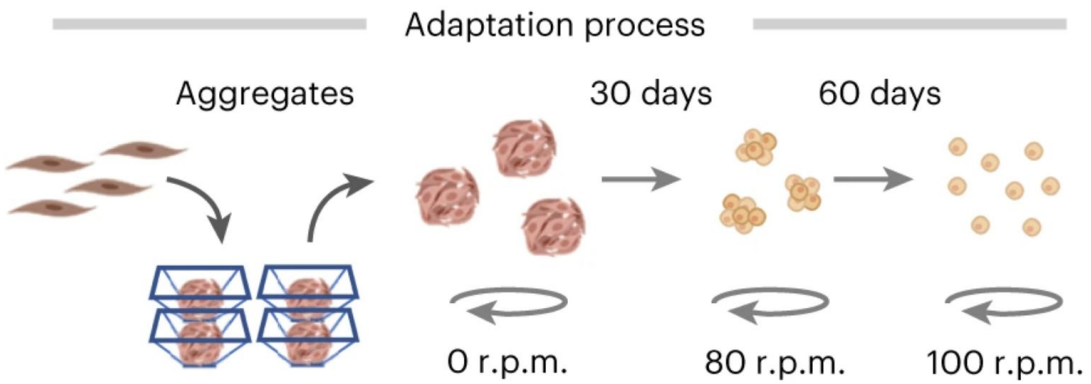
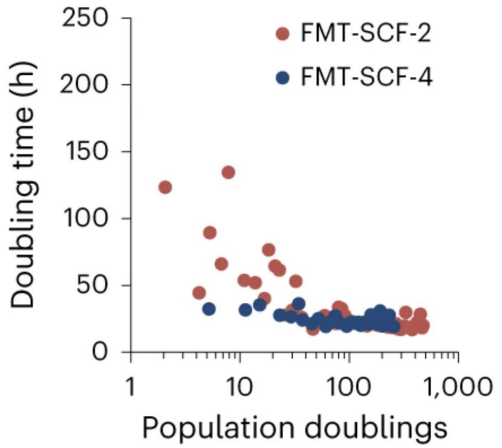
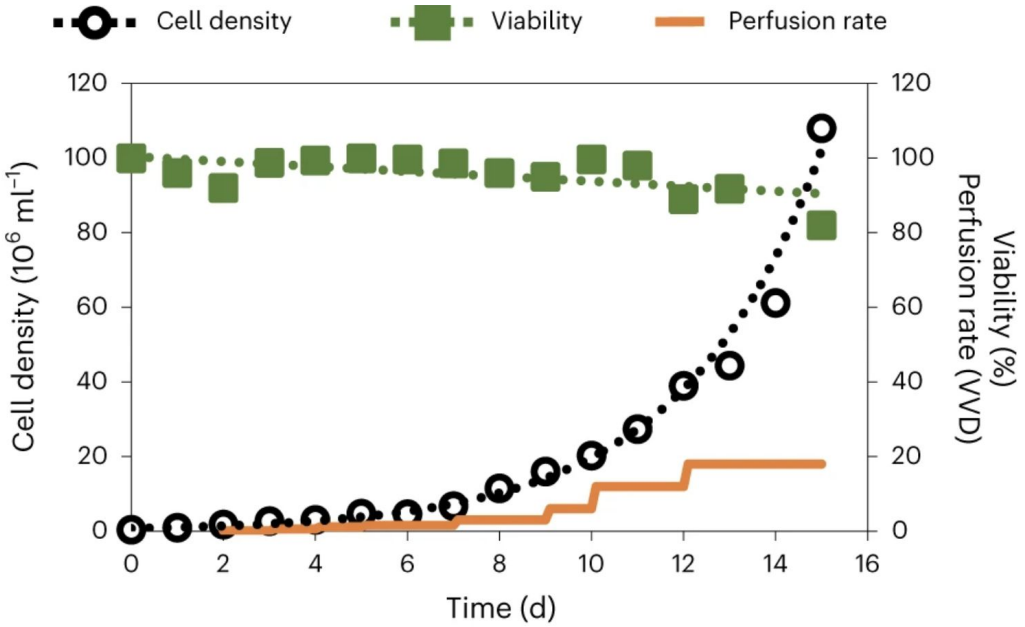
High-yield cell lines for serum-free production of cultivated meat





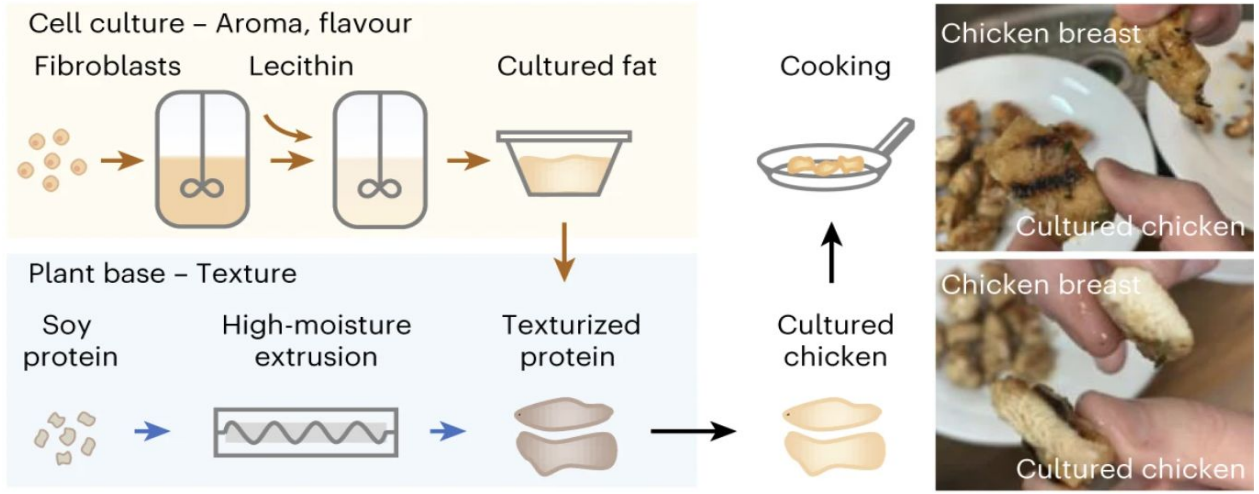


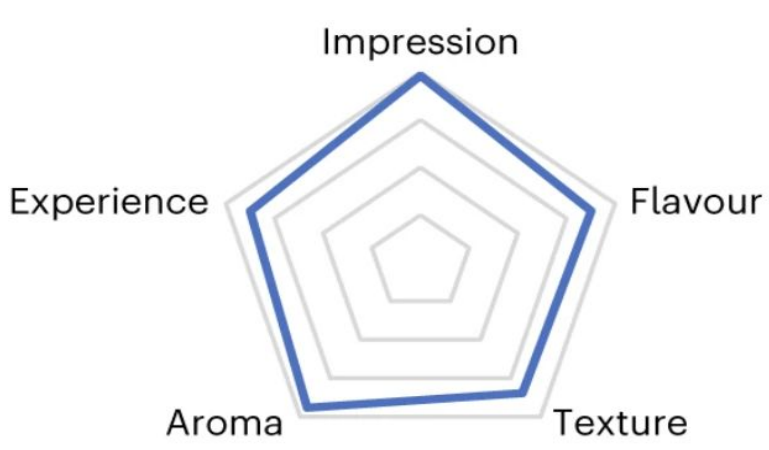
Summary of outcomes from three independent runs

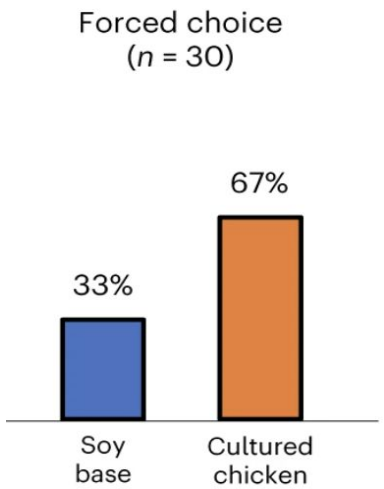
Run outcomes	Value
Max. cell density	99 ± 9 × 10^6 cells per ml
Glucose consumption	270 ± 34 g
Lactate production	150 ± 38 g
Ammonium production	2.2 ± 1 g
Accumulated base	332 ± 90 ml

Pasitka *et al.* (2022). *Nature Food*

High-yield cell lines for serum-free production of cultivated meat



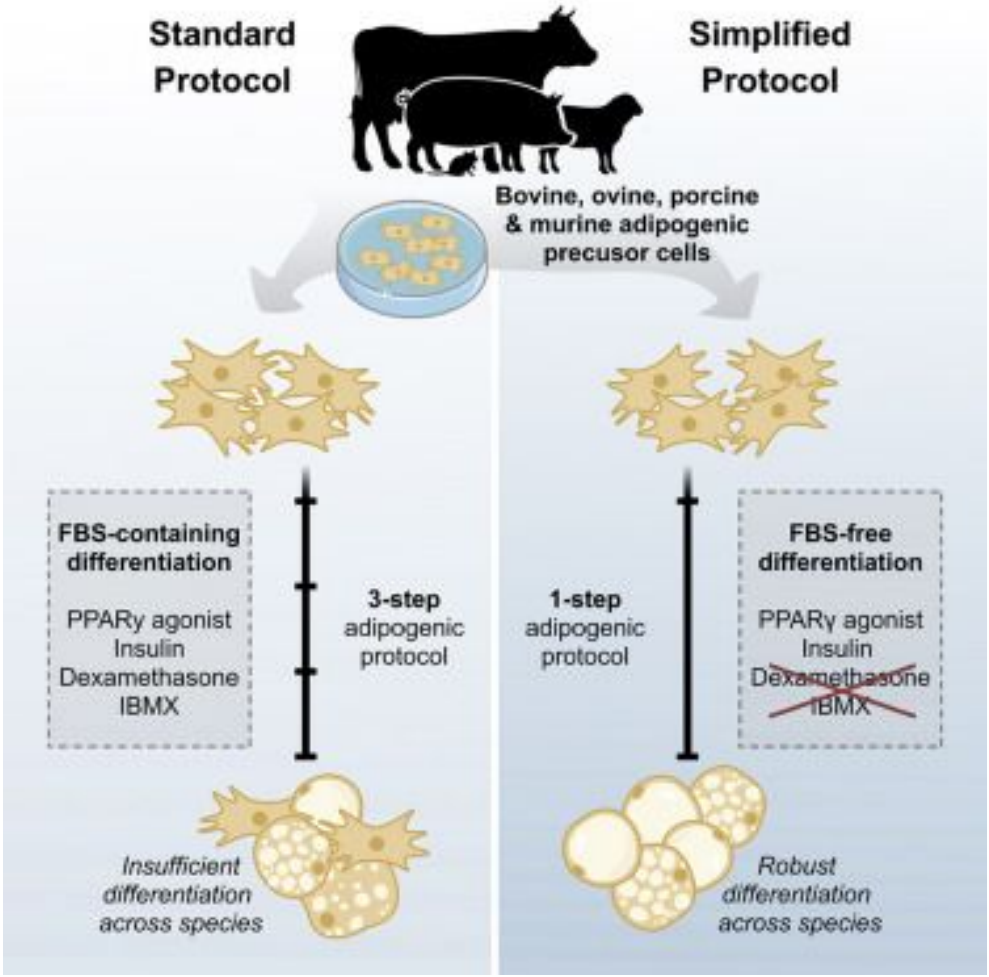




Nutrition Profile	Soy base	Cultured chicken	Chicken breast
Energy (kcal 100 g^{-1})	157.0	137.0	106.0
Protein (g 100 g^{-1})	22.5	19.1	19.8
Fat by hydrolysis (g 100 g^{-1})	4.7	4.5	2.9
Saturated fat (g 100 g^{-1})	0.4	0.7	0.9
Cholesterol (mg 100 g^{-1})	0.0	56.9	89.8
Carbohydrates (g 100 g^{-1})	1.0	0.8	0.1
Sodium (mg 100 g^{-1})	399.0	346.2	157.0
Ash for minerals (g 100 g^{-1})	1.0	0.9	1.2

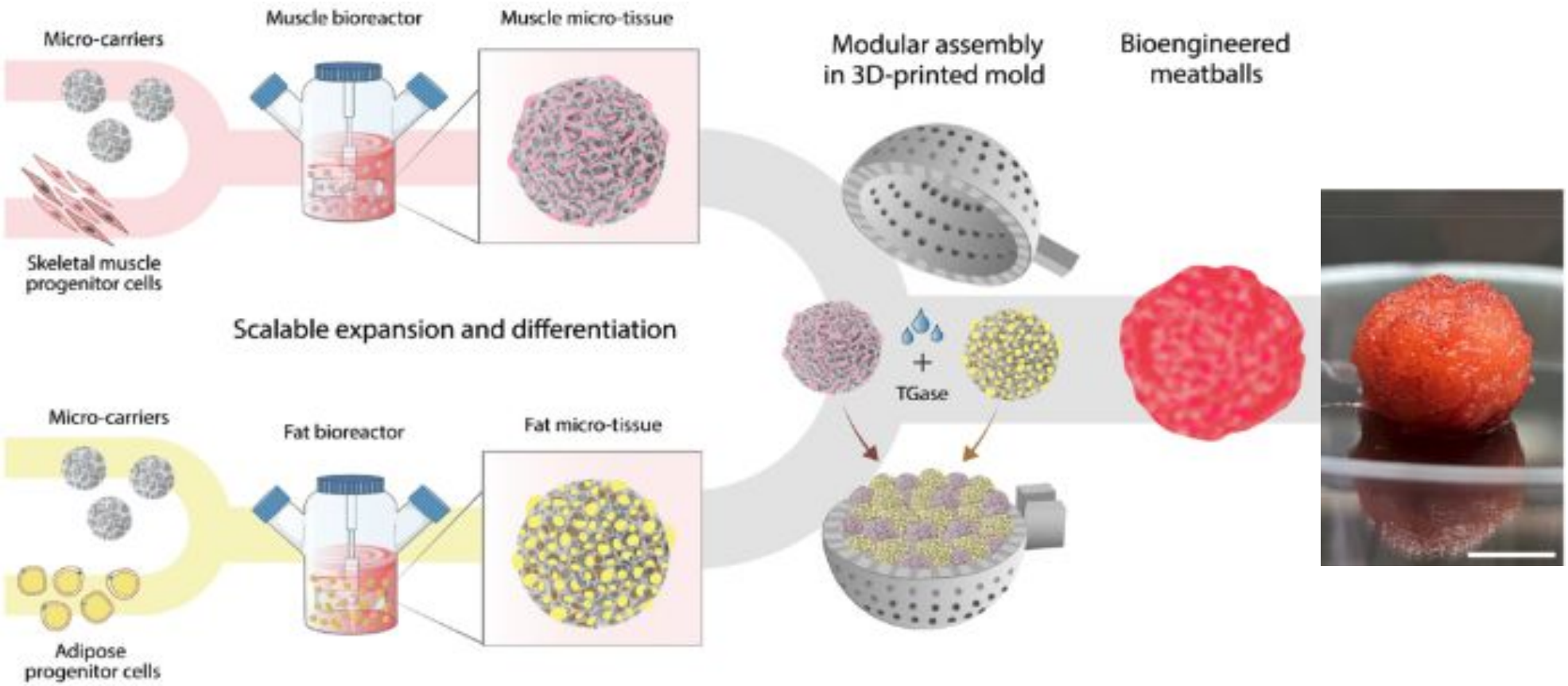
Pasitka *et al.* (2022). *Nature Food*

Serum-free media closer to being the norm



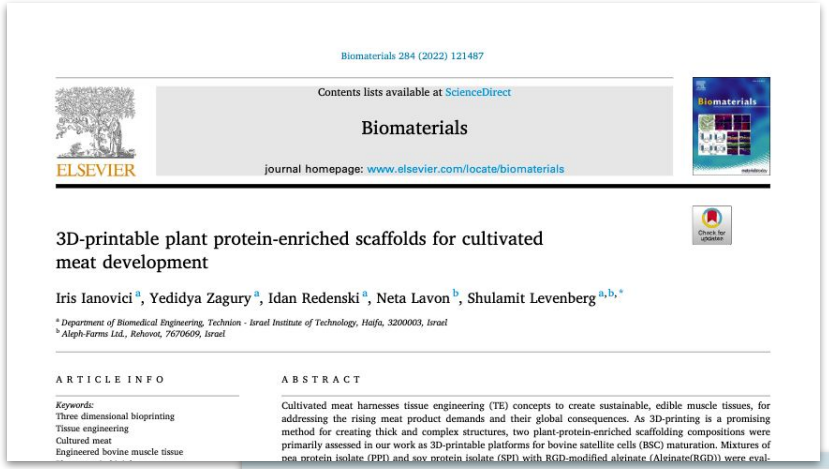
Mitic et al., *iScience*; Schenzle et al., *bioRxiv*

Advances in microcarriers



Cultivated meat companies are sharing insights

Aleph Farms



Biomaterials 284 (2022) 121487

Contents lists available at ScienceDirect

Biomaterials

journal homepage: www.elsevier.com/locate/biomaterials

3D-printable plant protein-enriched scaffolds for cultivated meat development

Iris Ianovici [a], Yedidya Zagury [a], Idan Redenski [a], Neta Lavon [b], Shulamit Levenberg [a,b,*]

[a] Department of Biomedical Engineering, Technion - Israel Institute of Technology, Haifa, 3200003, Israel
[b] Aleph-Farms Ltd., Rehovot, 7670609, Israel

ARTICLE INFO

Keywords:
Three dimensional bioprinting
Tissue engineering
Cultured meat
Engineered bovine muscle tissue

ABSTRACT

Cultivated meat harnesses tissue engineering (TE) concepts to create sustainable, edible muscle tissues, for addressing the rising meat product demands and their global consequences. As 3D-printing is a promising method for creating thick and complex structures, two plant-protein-enriched scaffolding compositions were primarily assessed in our work as 3D-printable platforms for bovine satellite cells (BSC) maturation. Mixtures of pea protein isolate (PPI) and soy protein isolate (SPI) with RGD-modified alginate (Alginate(RGD)) were eval-

BioTech Foods

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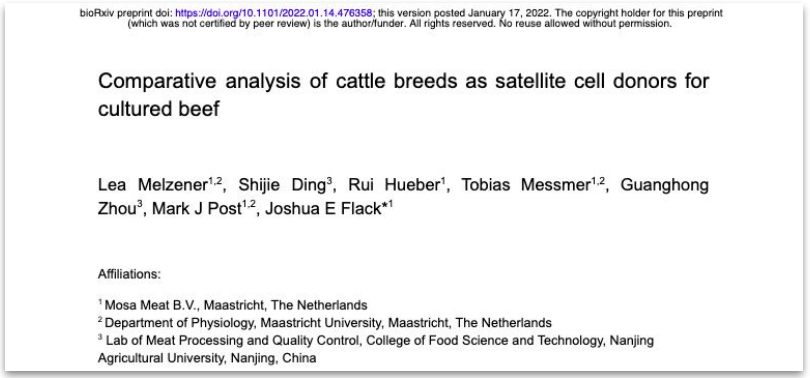
Application of texture analysis methods for the characterization of cultured meat

Jacobo Paredes[1,2], Diego Cortizo-Lacalle[3], Ane Miren Imaz[1,2], Javier Aldazabal[1,2] & Mercedes Vila[3]✉

Mechanical characterization supposes a key step in the development of cultured meat to help mimicking the sensorial properties of already existing commercial products based on traditional meat. This work presents two well stablished methods that can help studying cultured meat mechanical characteristics: texture profile analysis (double compression test) and rheology. These techniques

Mosa Meat



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Comparative analysis of cattle breeds as satellite cell donors for cultured beef

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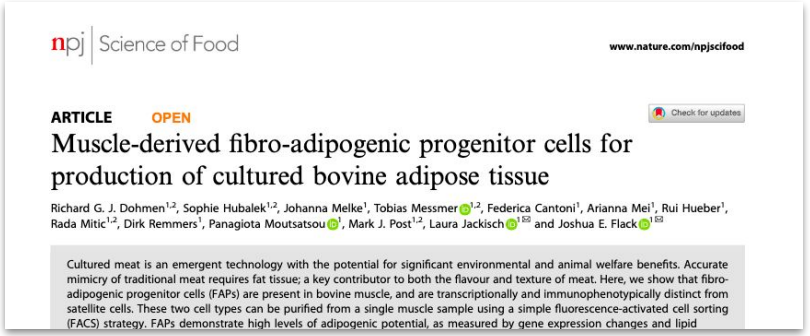

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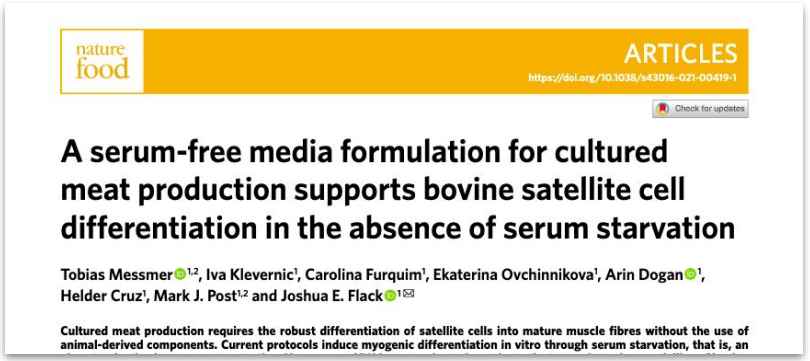
ARTICLE OPEN

Check for updates

Muscle-derived fibro-adipogenic progenitor cells for production of cultured bovine adipose tissue

Richard G. J. Dohmen[1,2], Sophie Hubalek[1,2], Johanna Melke[1], Tobias Messmer[1,2], Federica Cantoni[1], Arianna Mei[1], Rui Hueber[1], Rada Mitic[1,2], Dirk Remmers[1], Panagiota Moutsatsou[1], Mark J. Post[1,2], Laura Jackisch[1]✉ and Joshua E. Flack[1]✉

Cultured meat is an emergent technology with the potential for significant environmental and animal welfare benefits. Accurate mimicry of traditional meat requires fat tissue; a key contributor to both the flavour and texture of meat. Here, we show that fibro-adipogenic progenitor cells (FAPs) are present in bovine muscle, and are transcriptionally and immunophenotypically distinct from satellite cells. These two cell types can be purified from a single muscle sample using a simple fluorescence-activated cell sorting (FACS) strategy. FAPs demonstrate high levels of adipogenic potential, as measured by gene expression changes and lipid



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ARTICLES

https://doi.org/10.1038/s43016-021-00419-1

Check for updates

A serum-free media formulation for cultured meat production supports bovine satellite cell differentiation in the absence of serum starvation

Tobias Messmer[1,2], Iva Klevernic[1], Carolina Furquim[1], Ekaterina Ovchinnikova[1], Arin Dogan[1], Helder Cruz[1], Mark J. Post[1,2] and Joshua E. Flack[1]✉

Cultured meat production requires the robust differentiation of satellite cells into mature muscle fibres without the use of animal-derived components. Current protocols induce myogenic differentiation in vitro through serum starvation, that is, an

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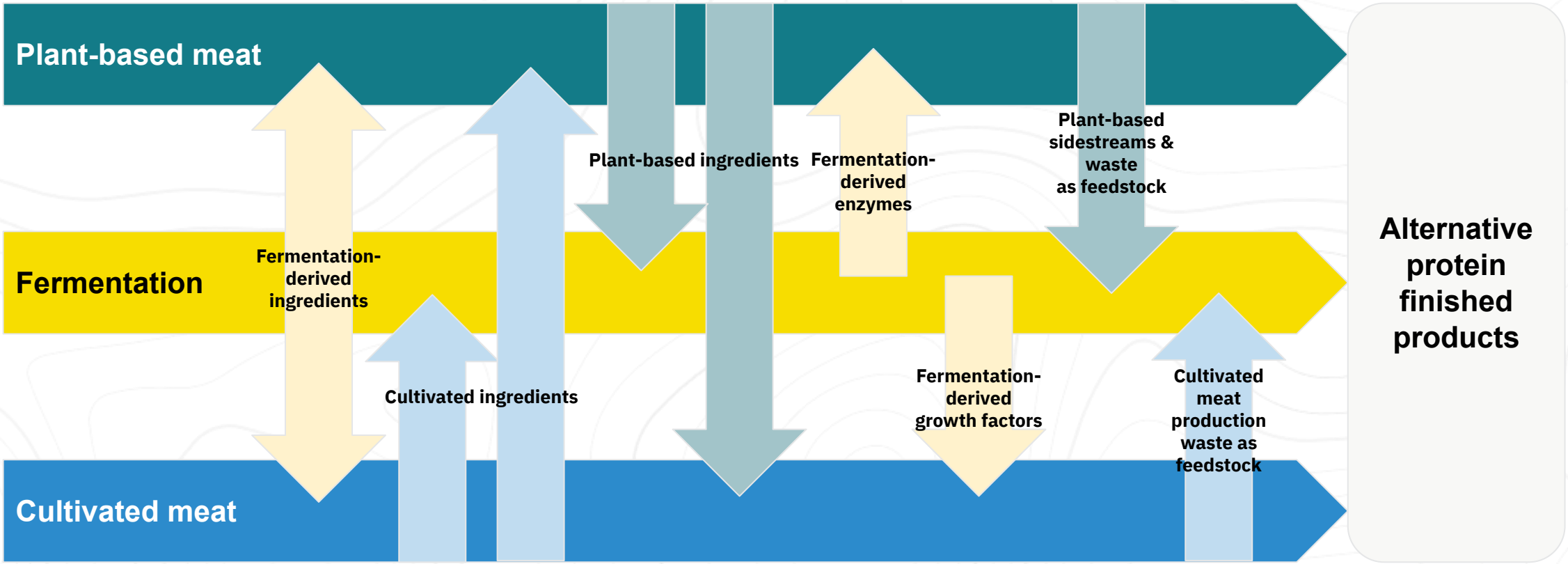
Agenda

1. GFI introduction
2. The Science: Three pillars of alternative proteins
3. Plant-based meat (PBM)
4. Fermentation-derived (FD) proteins/ingredients
5. Cultivated meat (CM)
6. **What the future holds**

Connections between alternative protein pillars

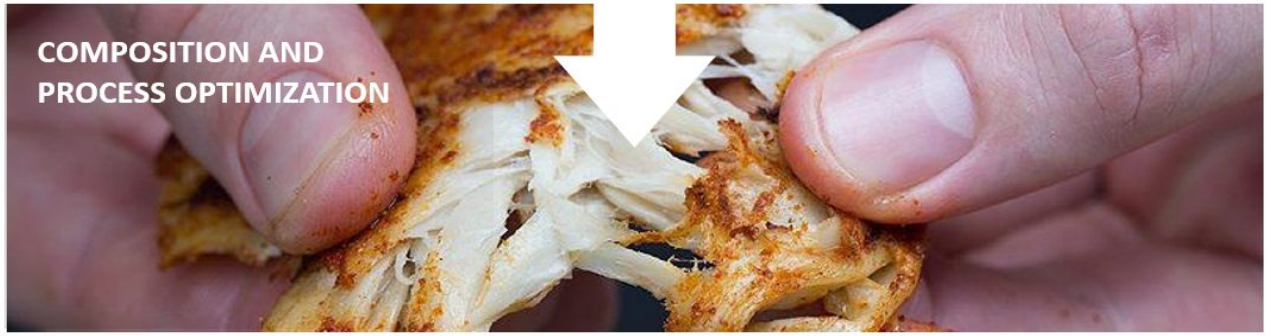


Data will be central to the next generation of PBM

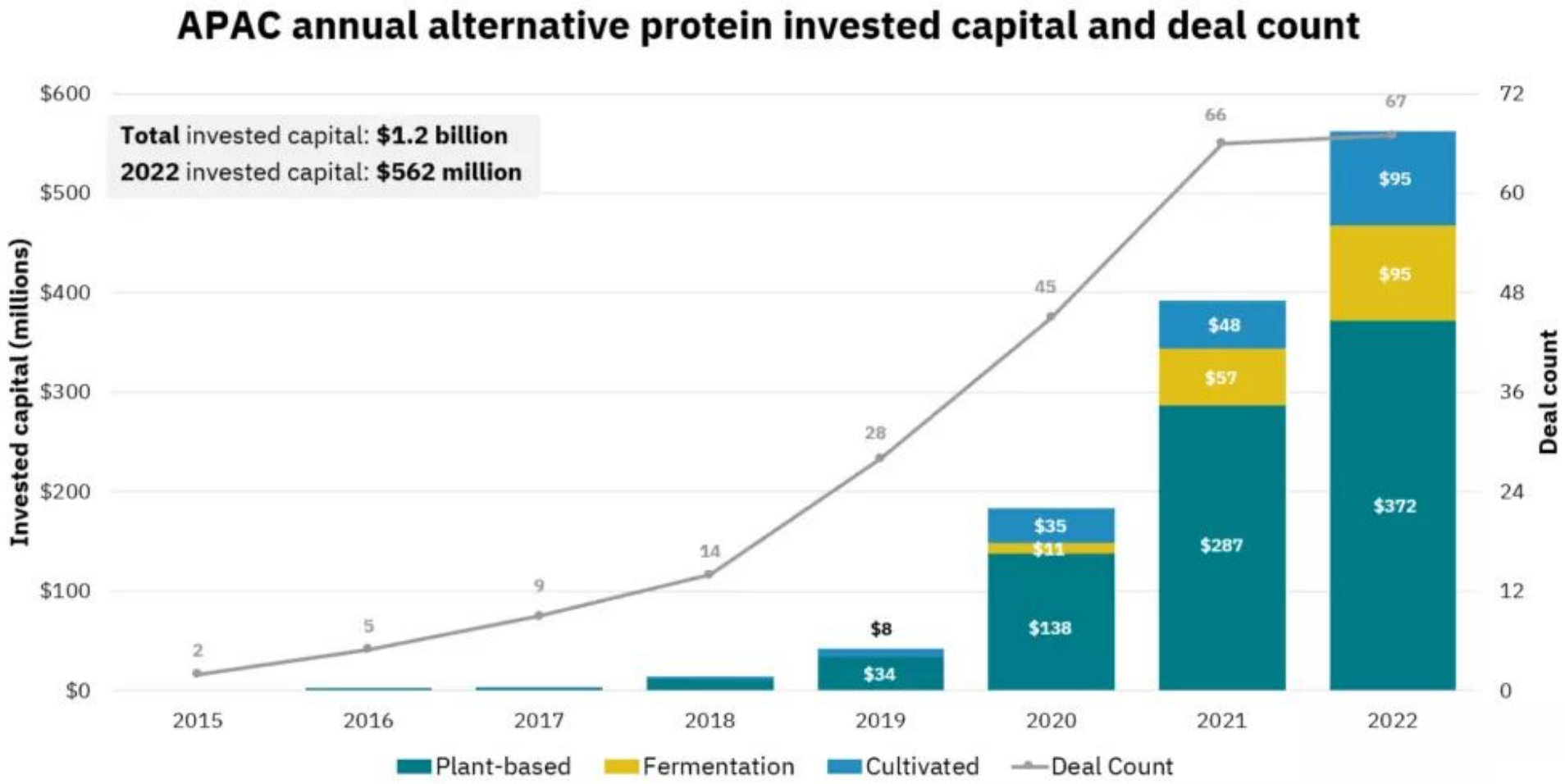
plant-based meat

DATA COLLECTION AND ANALYSIS

- GENOTYPE
- PHENOTYPE
- MACRONUTRIENTS
- MICRONUTRIENTS
- FUNCTIONALITY
- PROTEIN STRUCTURING
- CONSUMER PREFERENCE
- SOIL CONDITIONS



Investment across alternative proteins



Source: https://gfi-apac.org/defying-economic-headwinds-apac-alt-protein-investments-soared-in-2022/

Alternative protein market trend predictions for 2023

1. 
MORE FDA GREENLIGHT OF CULTIVATED MEAT

2. 
MERGERS AND ACQUISITION

3. 
ALTERNATIVE PROTEIN ALIGNMENT WITH ESG INVESTING

4. 
CORPORATIONS PARTNERING WITH ALT PROTEIN COMPANIES

5. 
SCALE UP FACILITIES TAKE CENTRE STAGE

6. 
CONSUMER INSIGHTS AS A KEY DEVELOPMENT TOOL

7. 
RISK ASSESSMENTS AS GROUNDWORK FOR AGILE STARTUPS

Source: https://gfi.org/blog/the-top-7-alternative-protein-trends-fueling-optimism-in-2023//

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Thank you!

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