

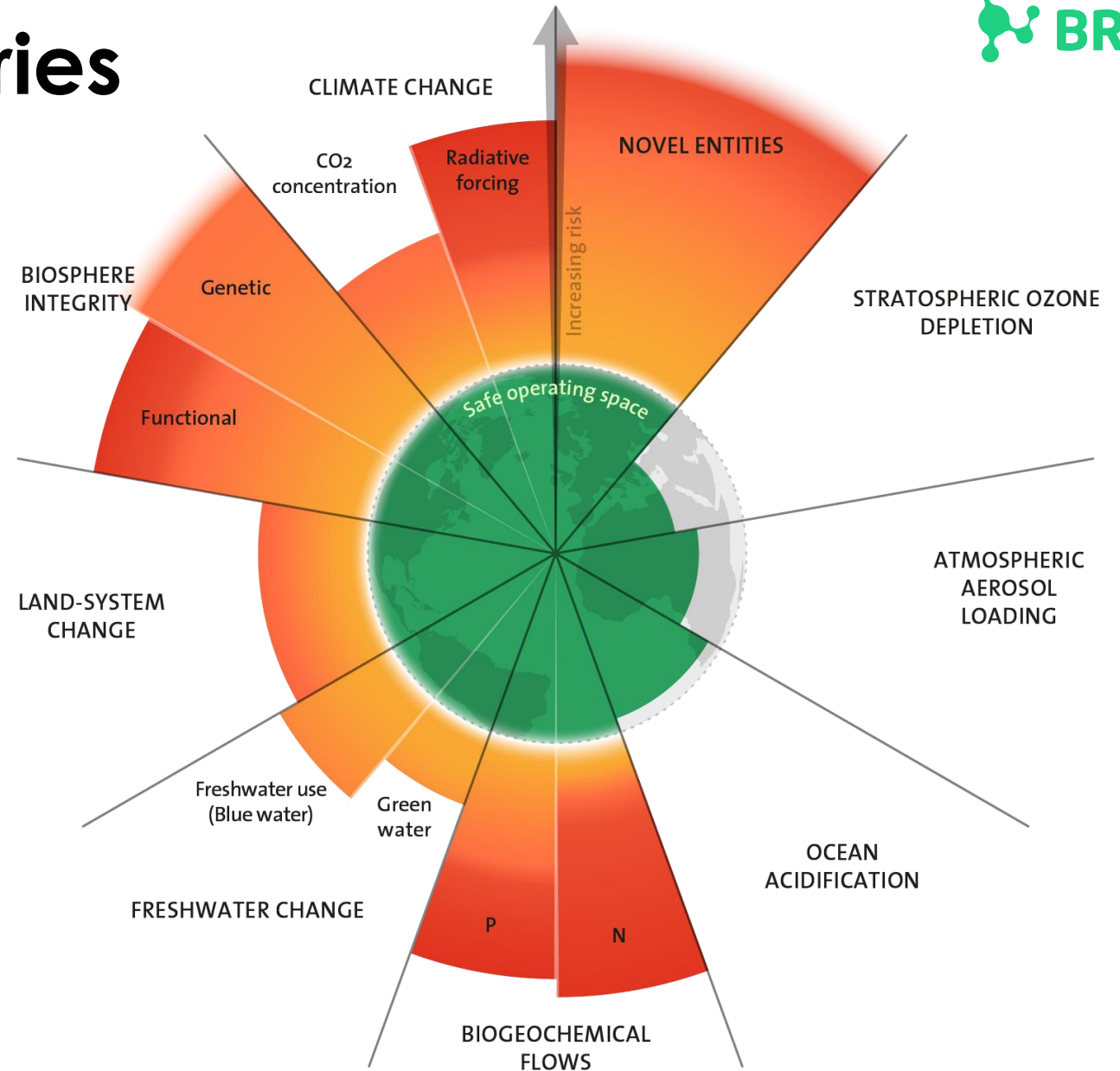
Fermenting within the Planetary Boundaries: Microbial and Fungal Foods Frontiers

Tiffany Mak

Researcher & Project Lead

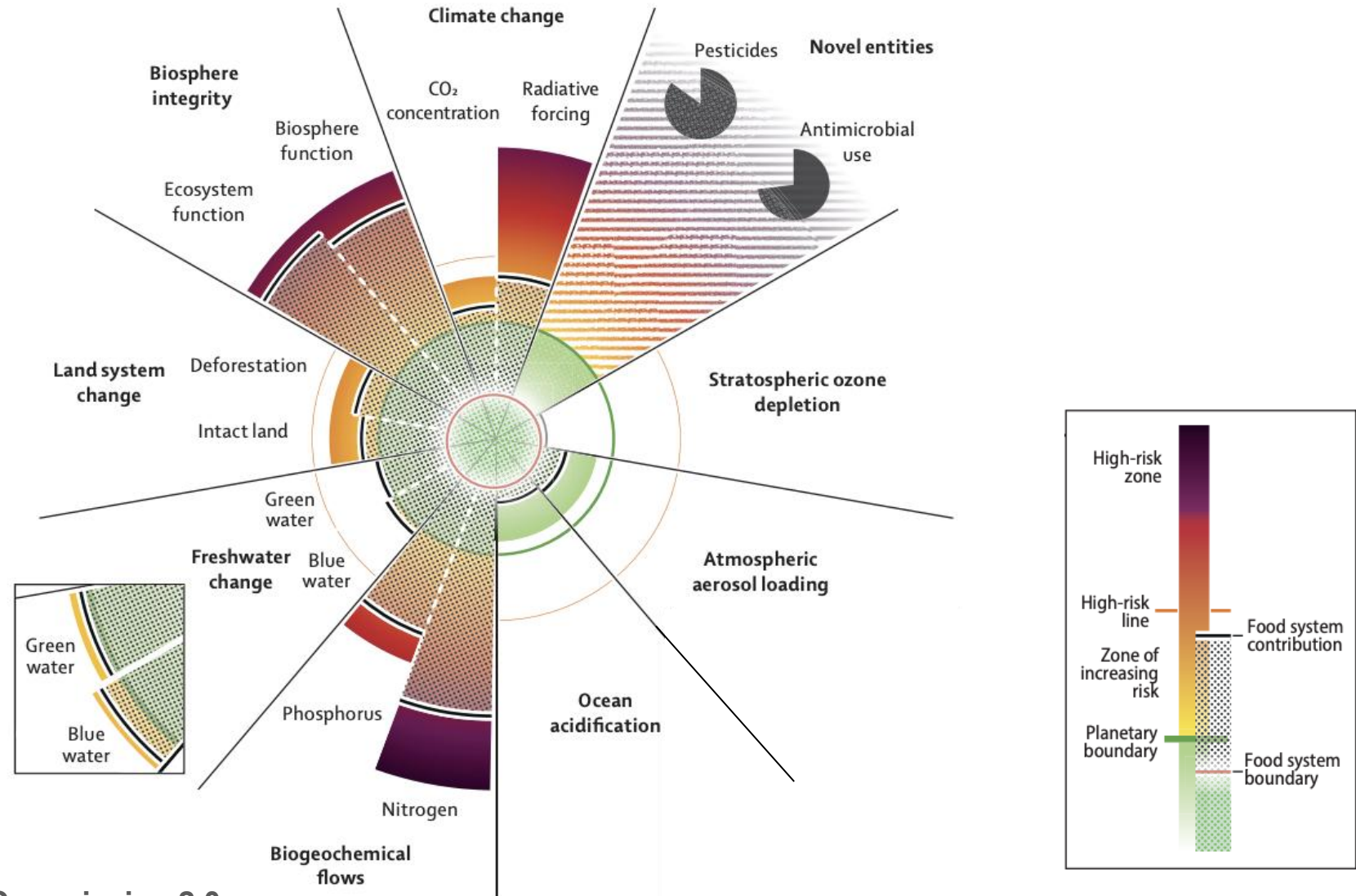
tifmak@dtu.dk

Planetary Boundaries



Source: Stockholm Resilience Centre

What has food got to do with the Planet?



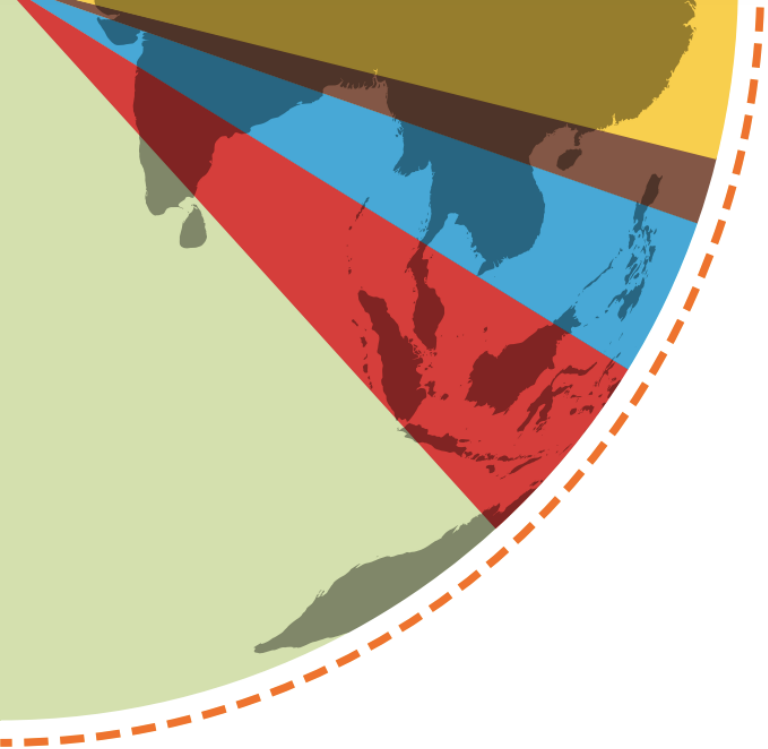
Rockström *et al.* 2025, The EAT-Lancet Commission 2.0

What has food got to do with the Planet?

- The global food sector currently accounts for at least 30% of the total energy consumption in the world¹
- Based on current consumption patterns, food production is projected to increase by 60-70% to meet increasing demands under the current infrastructure²

¹ FAO Issue Paper, 2011

² Alexandratos, N. & Bruinsma, J. (2012)



Summary Report of the EAT-Lancet Commission

Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems



Walter Willett, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett, David Tilman, Fabrice DeClerck, Amanda Wood, Malin Jonell, Michael Clark, Line J Gordon, Jessica Fanzo, Corinna Hawkes, Rami Zurayk, Juan A Rivera, Wim De Vries, Lindiwe Majele Sibanda, Ashkan Afshin, Abhishek Chaudhary, Mario Herrero, Rina Agustina, Francesco Branca, Anna Lartey, Shenggen Fan, Beatrice Crona, Elizabeth Fox, Victoria Bignet, Max Troell, Therese Lindahl, Sudhvir Singh, Sarah E Cornell, K Srinath Reddy, Sunita Narain, Sania Nishtar, Christopher J L Murray

Healthy Diets From
Sustainable Food Systems

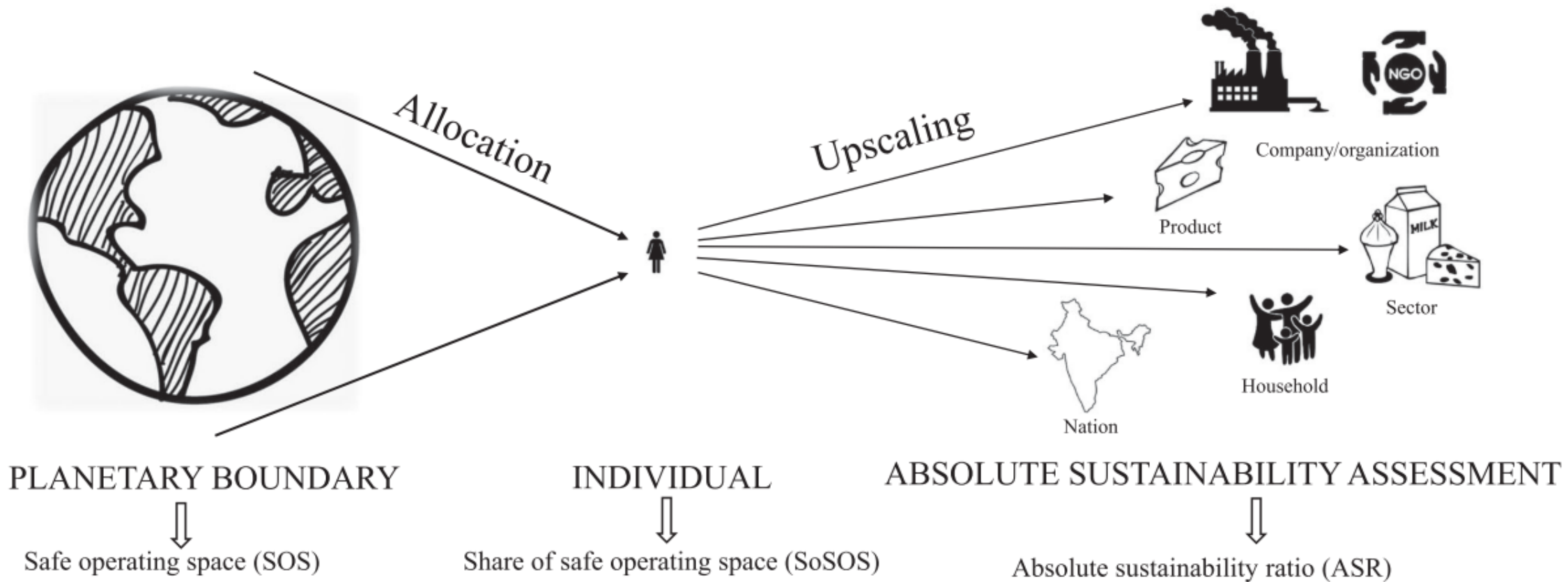
Food Planet Health



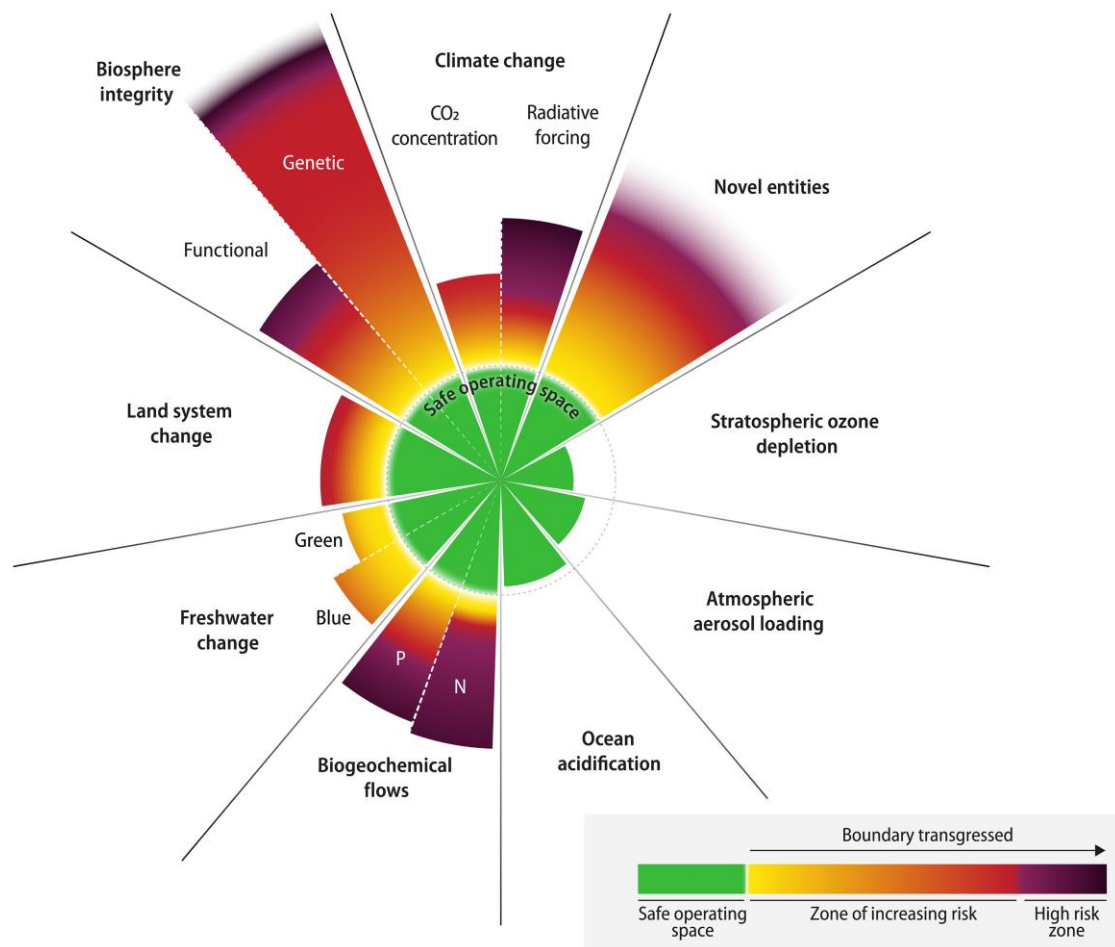
“Food is the single strongest lever to optimize human health and environmental sustainability on Earth.”

Willett *et al.* 2019, *The Lancet*

How do we assess impact?



The PB-LCIA approach to Absolute Sustainability



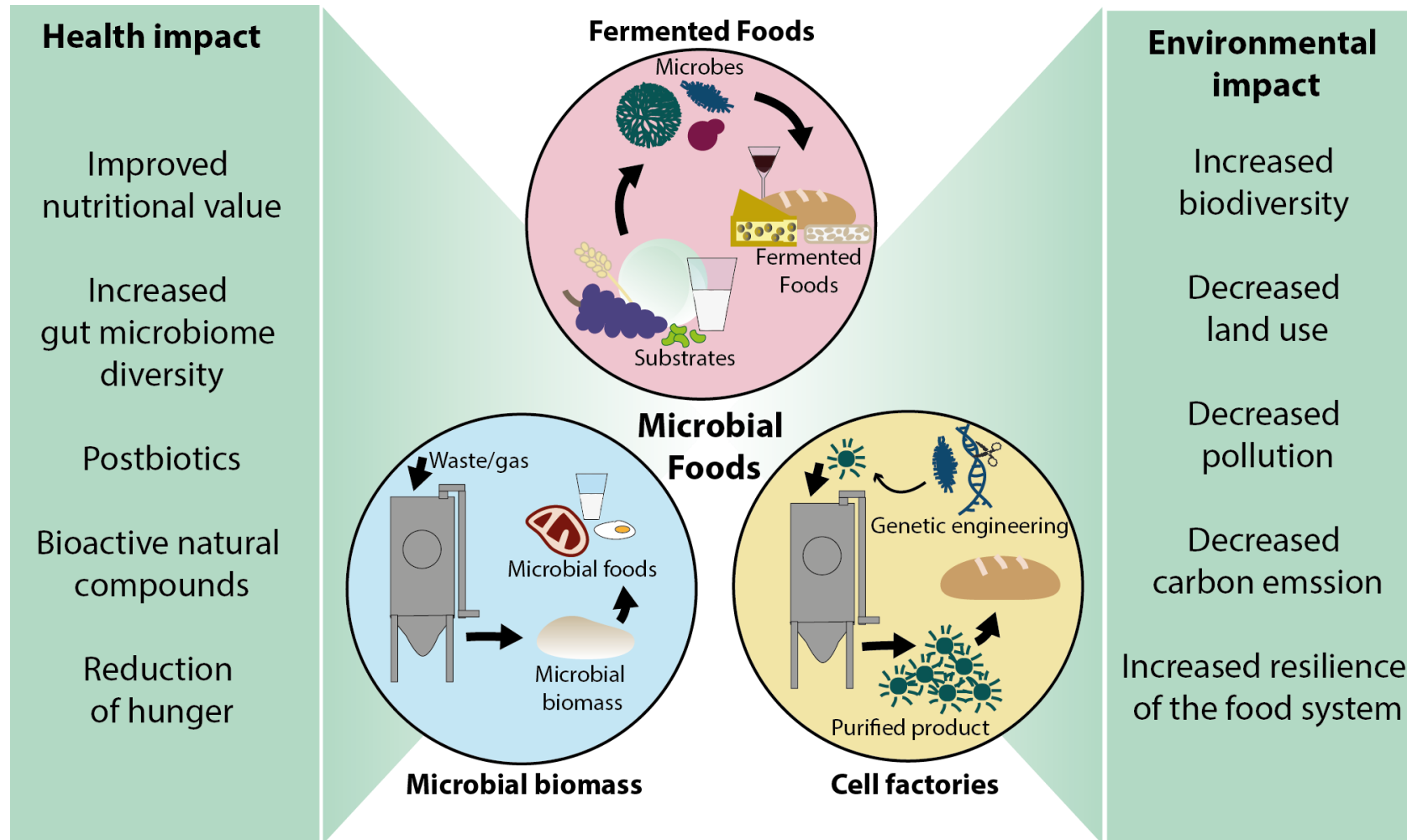
Planetary Boundaries (PB)



Life Cycle Impact Assessment (LCIA)

Where do microbes & fermentation come in?

Microbial foods: an overview



Jahn et al., 2023 *Cell*

Spectrum of microbial food innovations



Lessons from the Field: Microbial and fungal food frontiers

1. Exploring (bio)diversity

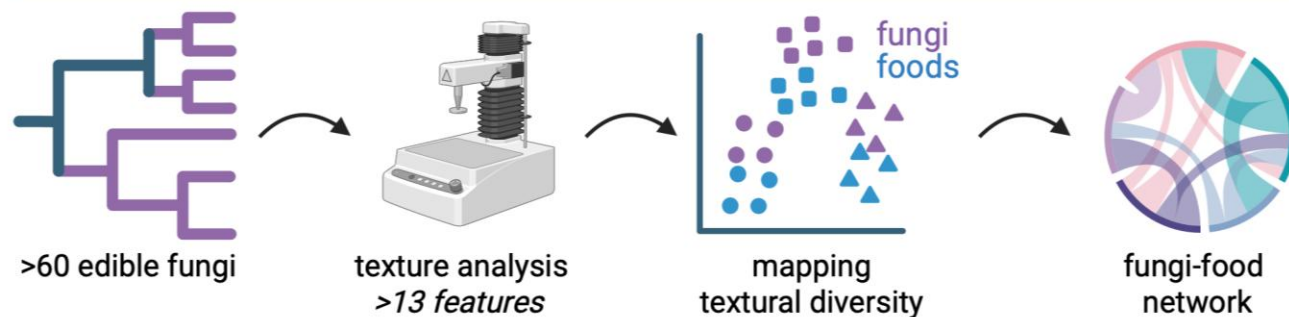


Photo courtesy of Leonie Jahn and Loes van Dam

The textural landscape of filamentous fungi

1. The Textural Landscape of Fungal Biomass

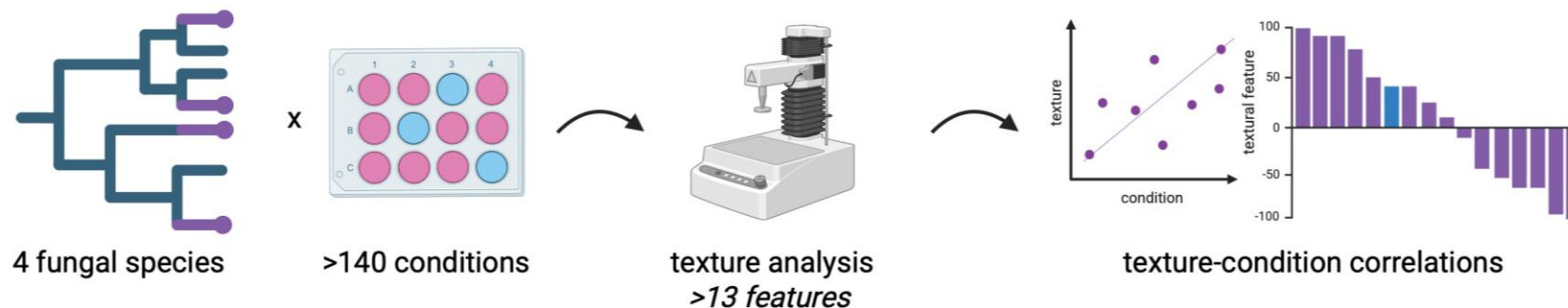
Systematic mapping of textural properties of edible fungal mycelium across the fungal phylogeny



Loes van Dam
lovada@dtu.dk

2. Textural Engineering of Edible Fungi

Effects of growth conditions and genetic determinants of texture in mycelium of filamentous fungi

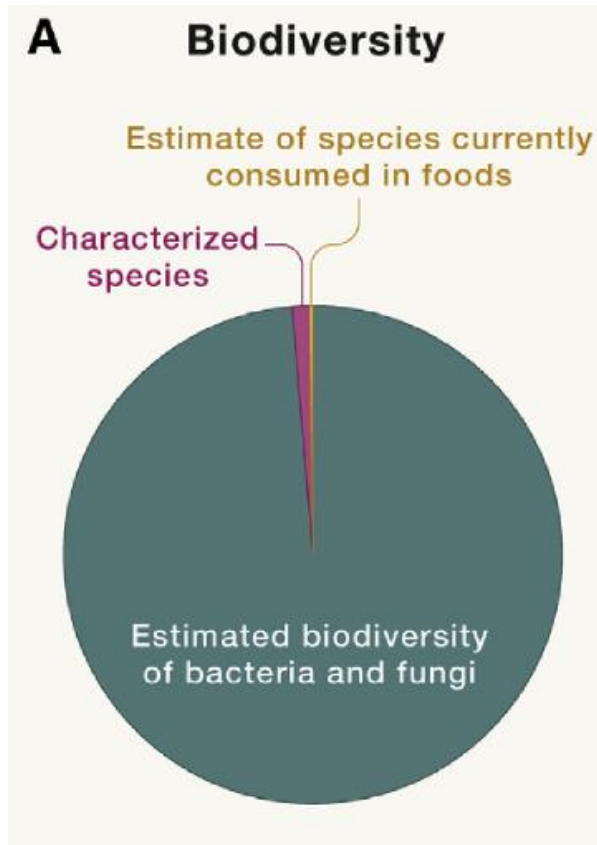
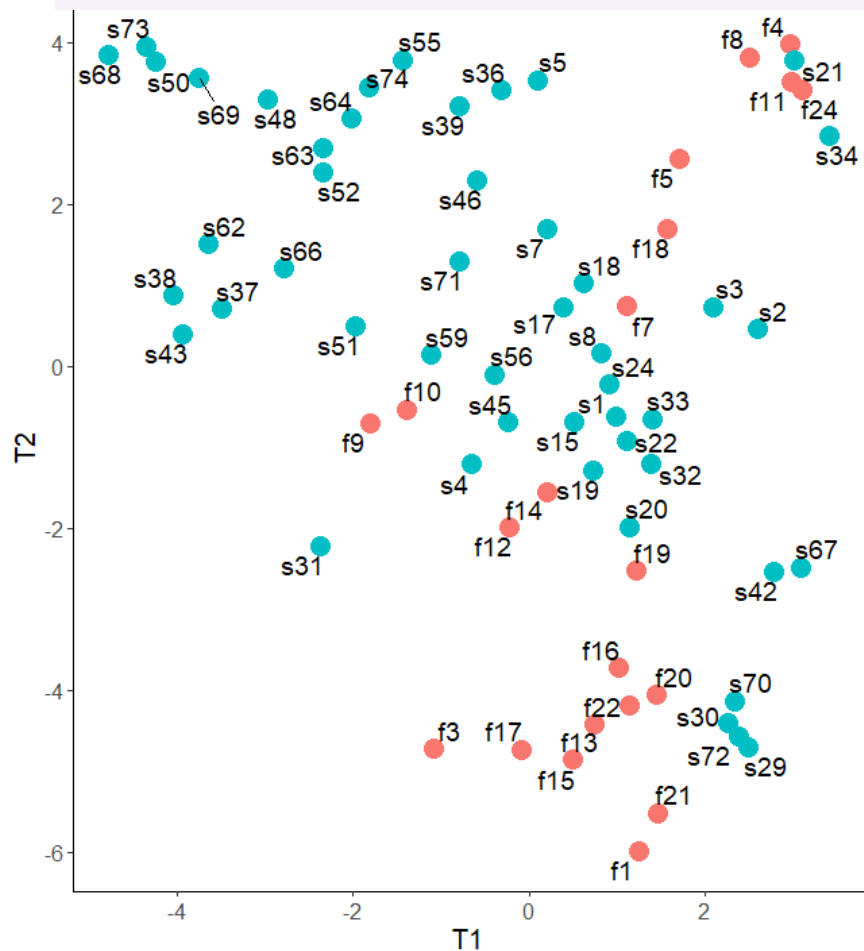


PI: Leonie Jahn
lejj@dtu.dk

The diversity of fungal textures

Texture analysis of mycelium

red: food - blue: mycelium

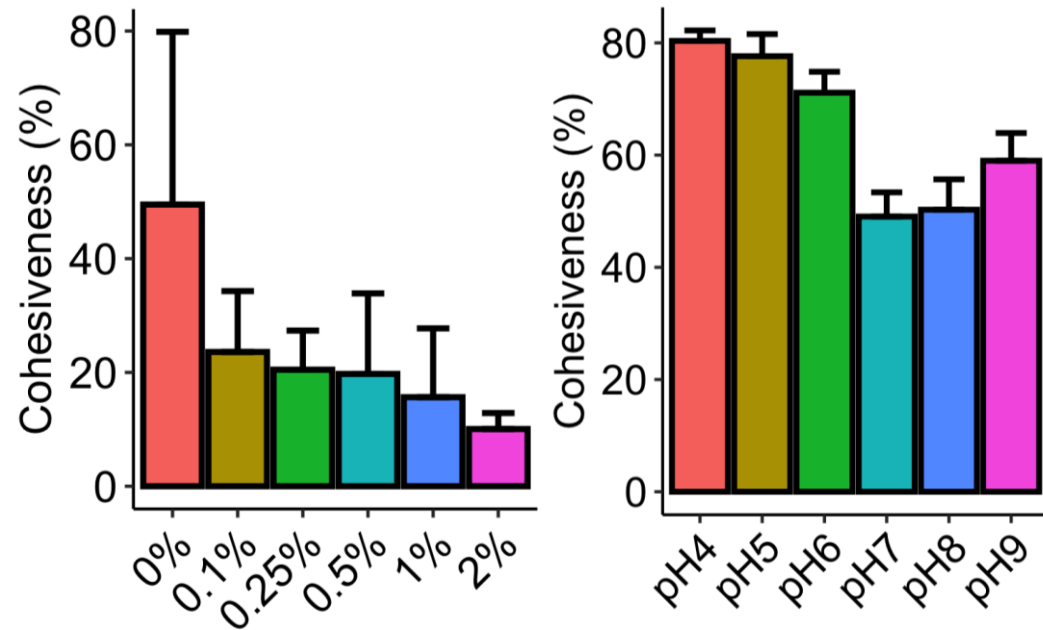


Jahn et al., 2023

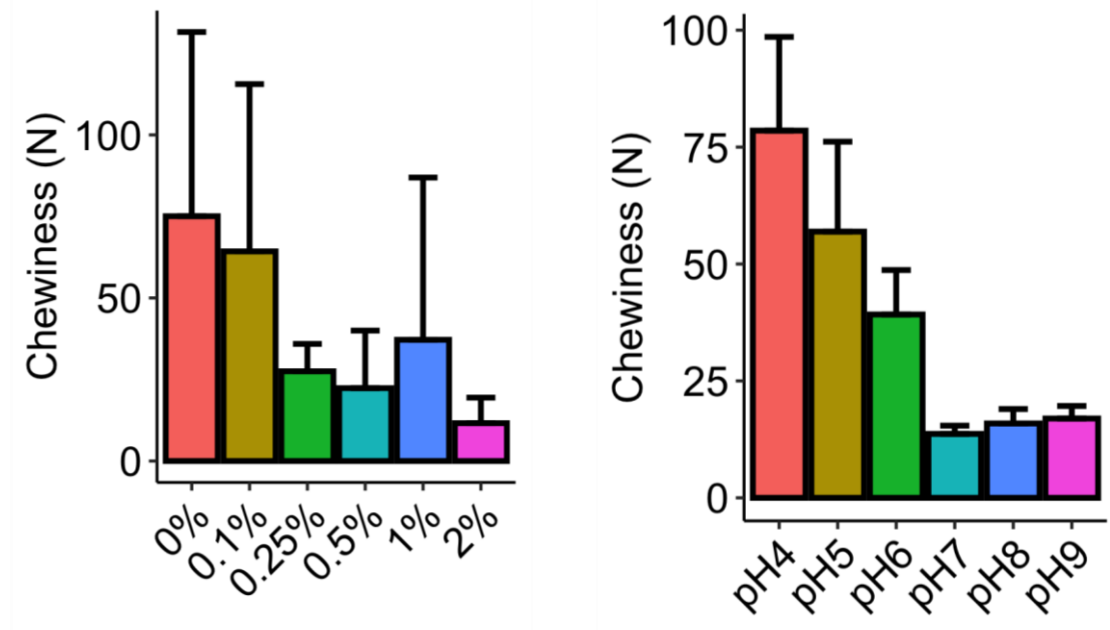


How do growth conditions affect mycelium texture?

cohesiveness



chewiness

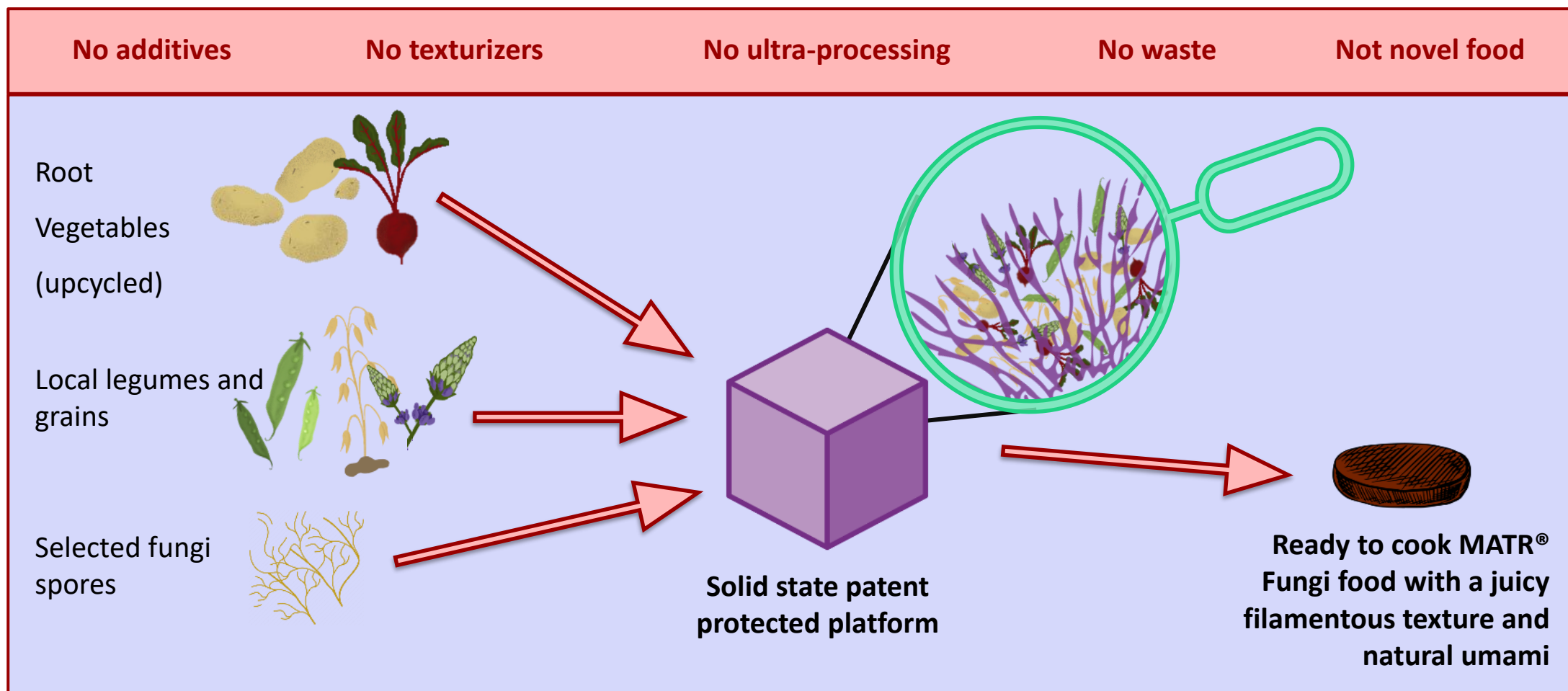


2. Potentials of Solid State Fermentation (SSF)



MATR foods: pioneering a new category of fermented plant based whole foods

MATR



MATR foods: lower climate footprint than any meat or current alternatives

“I think it has a brilliant texture and it tastes amazing.”



Rasmus Kofoed

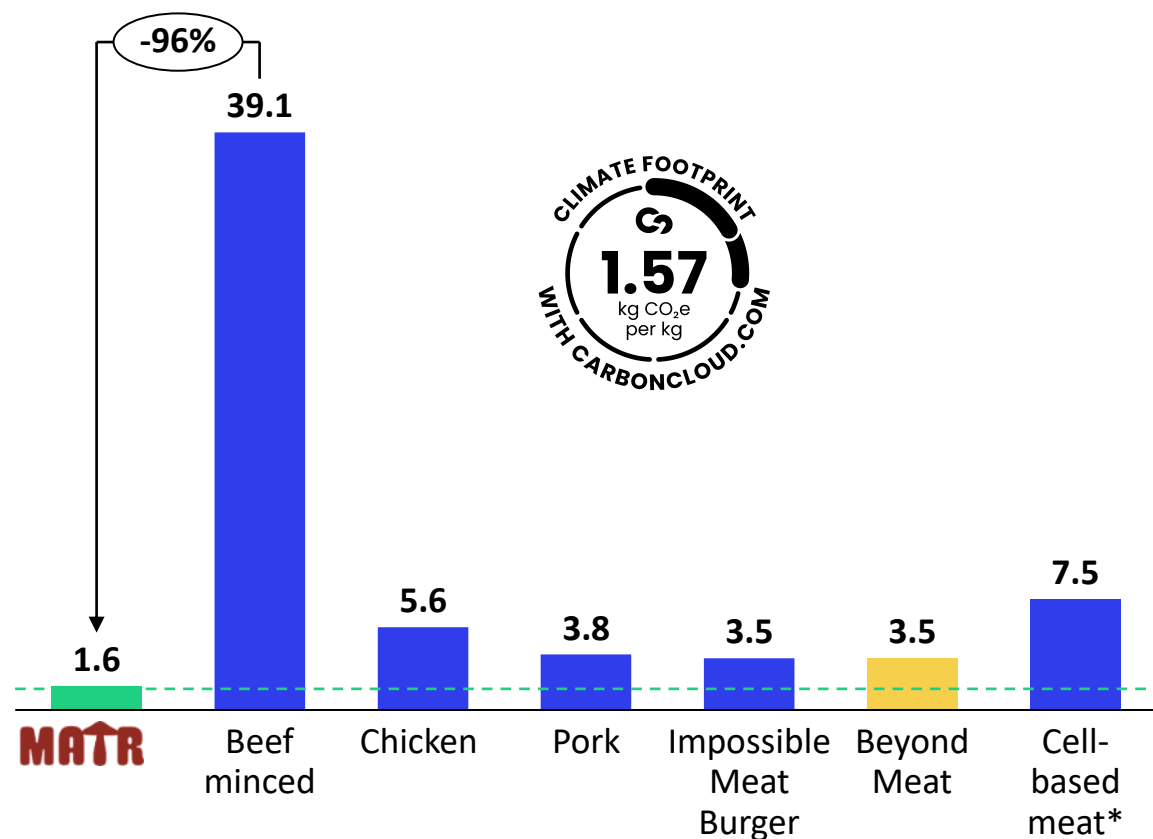
Best Restaurant in the World

Three Michelin Stars, Bocuse d'Or Gold medal



Lower footprint than any meat or current alternative

CO_{2e}/kg of finished product



Challenges



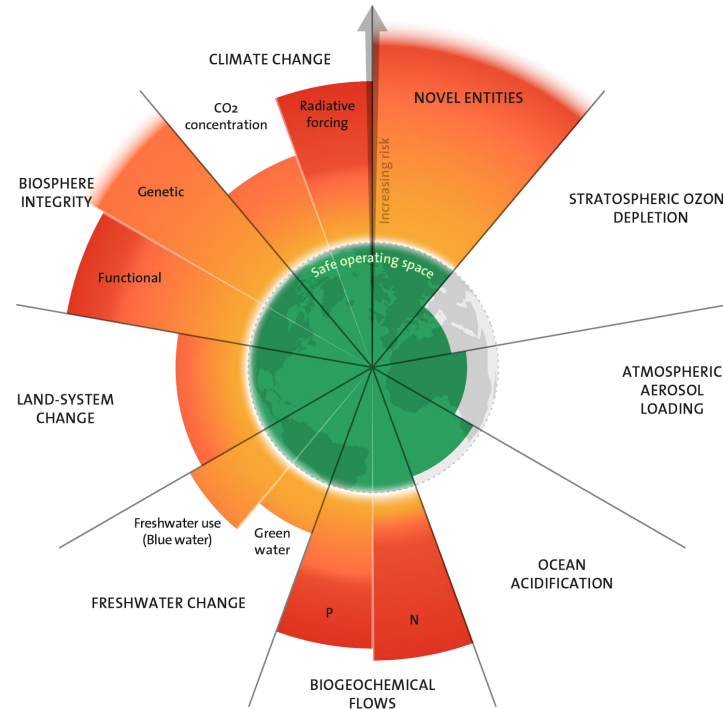
**(Myco)toxins /
Secondary
Metabolites?**

Safety?

Production

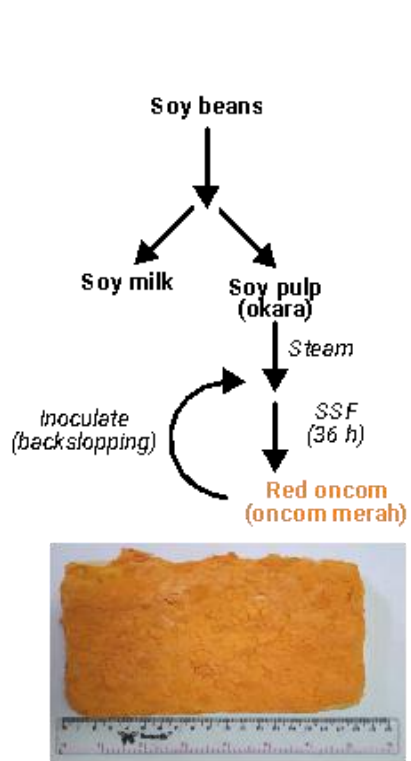


**Novel Foods
Regulations?**



Constraints as a Driver for Change: Cultivating a sustainable innovation ecosystem

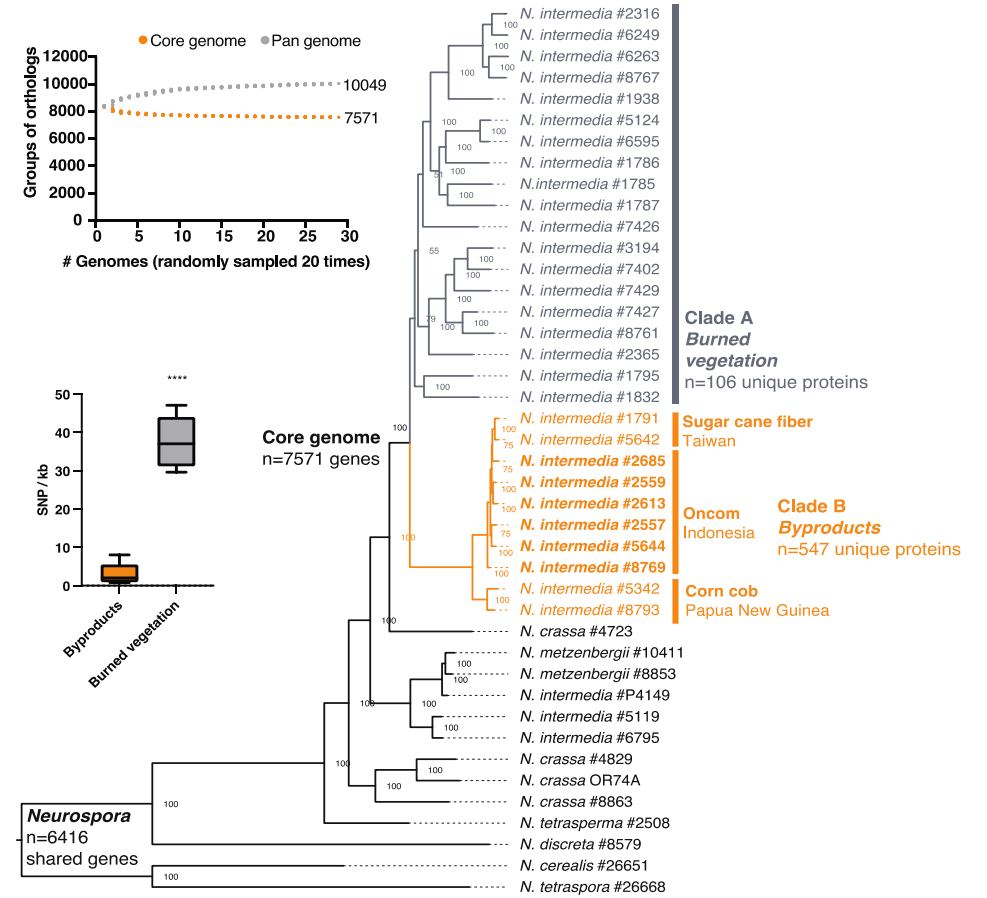
Waste to Food: converting inedible waste into food through fungal fermentation



Burned vegetation

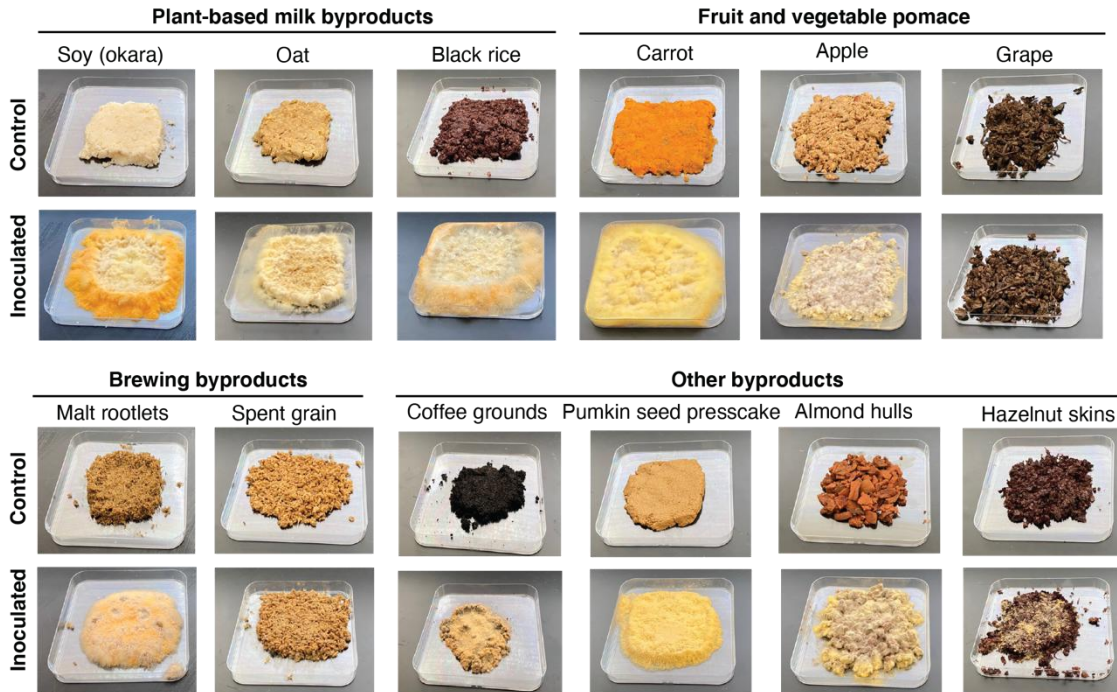


byproducts

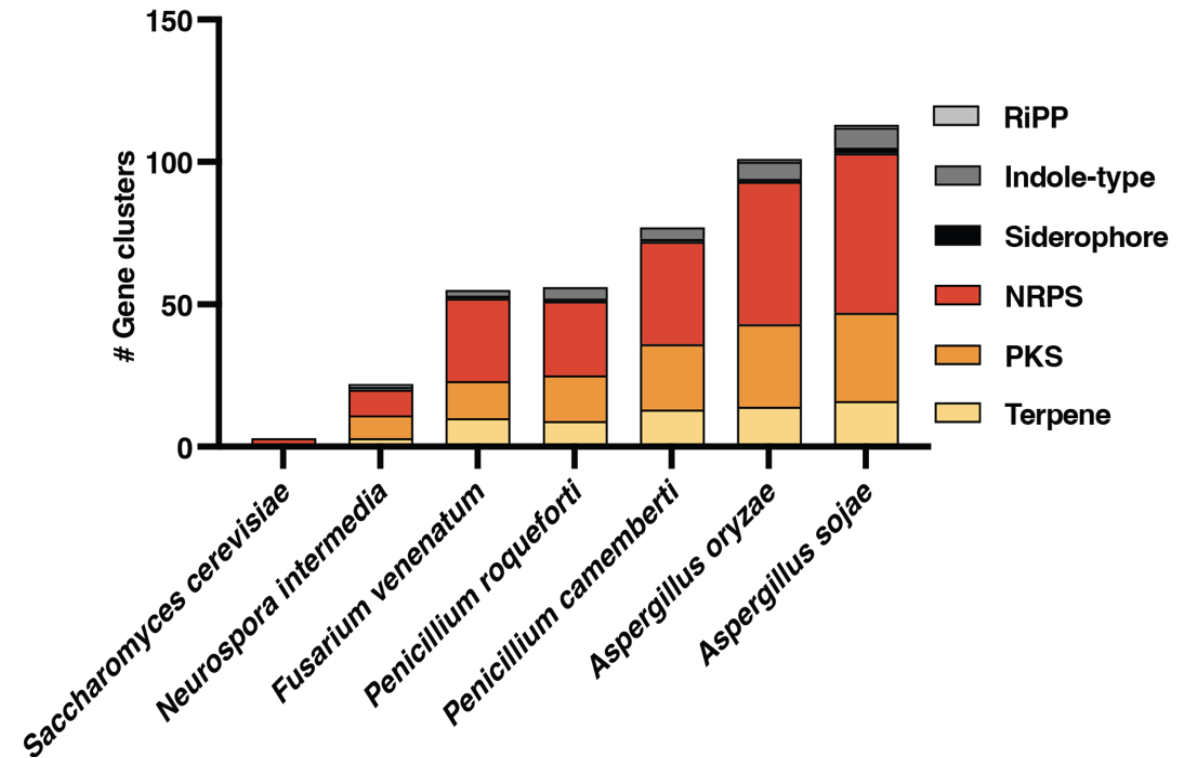


N. intermedia has the potential to transform byproducts into safe to eat food

N. Intermedia can convert many byproducts into food



N. Intermedia has a simple secondary metabolite profile



Hill-Maini et al., 2024 *Nature Microbiology*

Circular (bio)economy: Alternative feedstocks for yeast biomass production



Candela Sanchez-Giron Barba

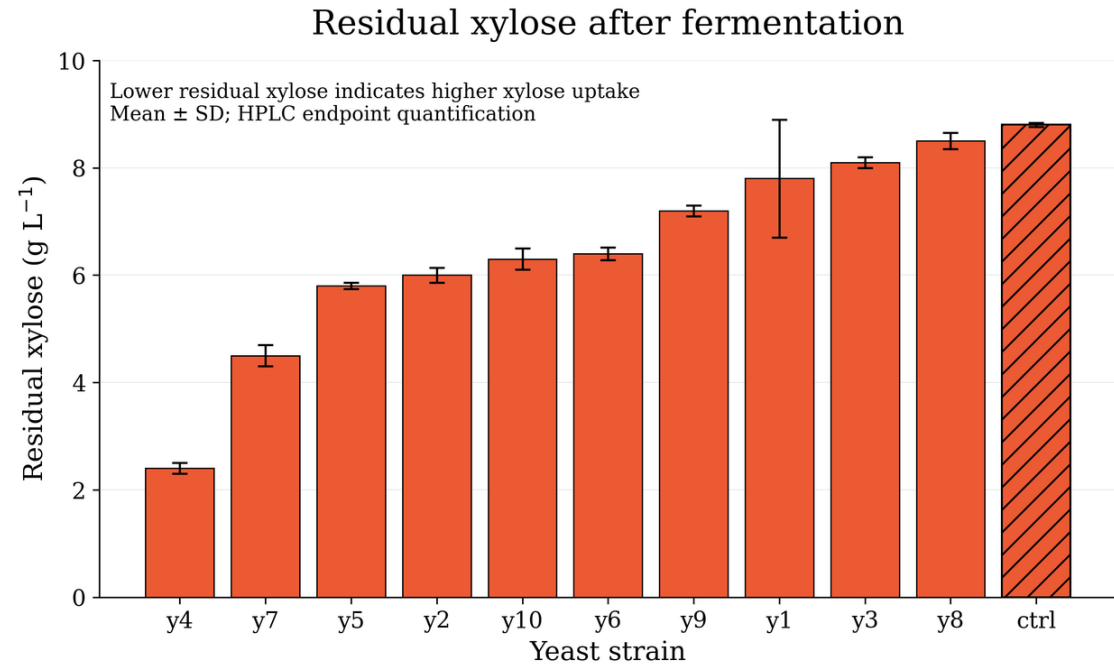


Alexandros Karyolaimos

¹ Santos et al., 2025

Screening yeast for glucose and xylose co-utilisation

- Yeast biomass production currently relies on hexose sugar-rich feedstocks
- Lignocellulosic agro-industrial waste contains large amounts of xylose
- Screening strains for xylose uptake enables alternative substrates for biomass production



- Several strains demonstrated partial xylose co-utilisation in the presence of glucose.
- Strain 4 showed the highest native xylose uptake capacity

Field-to-Fork: Connecting sustainable field management strategies to microbial foods production



Perennial crops used as substrates to develop food products through fungal fermentation

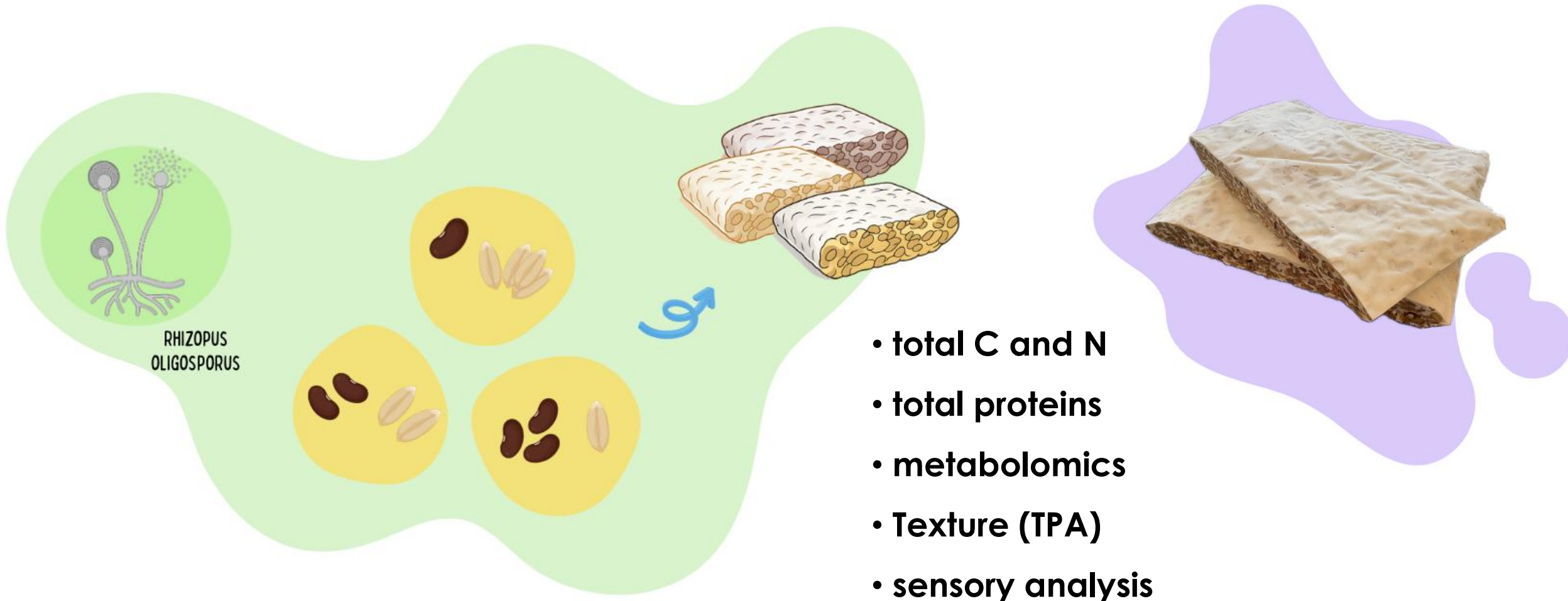
Advantages of perennial crops

- drought resistance, deep-rooted
- reduced mechanical soil cultivation
- nutrient rich
- enhanced N-fixing



Marilena Feller

Characterisation of “novel” tempeh – correlating between substrate composition, nutrition and flavour



TRANSITIONING FROM A LINEAR ECONOMY...



1.2bn tonnes

of food is lost on farms annually¹



931m tonnes



of food is wasted at the consumption level (retail, food services and households) annually²

...TO A CIRCULAR ECONOMY

12 RESPONSIBLE CONSUMPTION AND PRODUCTION



Transitioning to a circular economy contributes to the achievement of the UN SDGs, including **SDG 12.**



SOURCES: ¹ European Commission, 2016; ² WWF, 2021; ³ UNEP, 2021

Thank you!

Microbial Foods Group

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Institute

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Landbrug og Fiskeri
gudp

/novation Fund Denmark

