

Advancing the Bioeconomy with Mycoprotein: Insights from the Plenitude project

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Introduction to ENOUGH

ENOUGH



ENOUGH is a food-tech company growing the most sustainable source of food protein – ABUNDA® mycoprotein.

Founded in 2015 in the UK and completed installation of first production site in 2023.

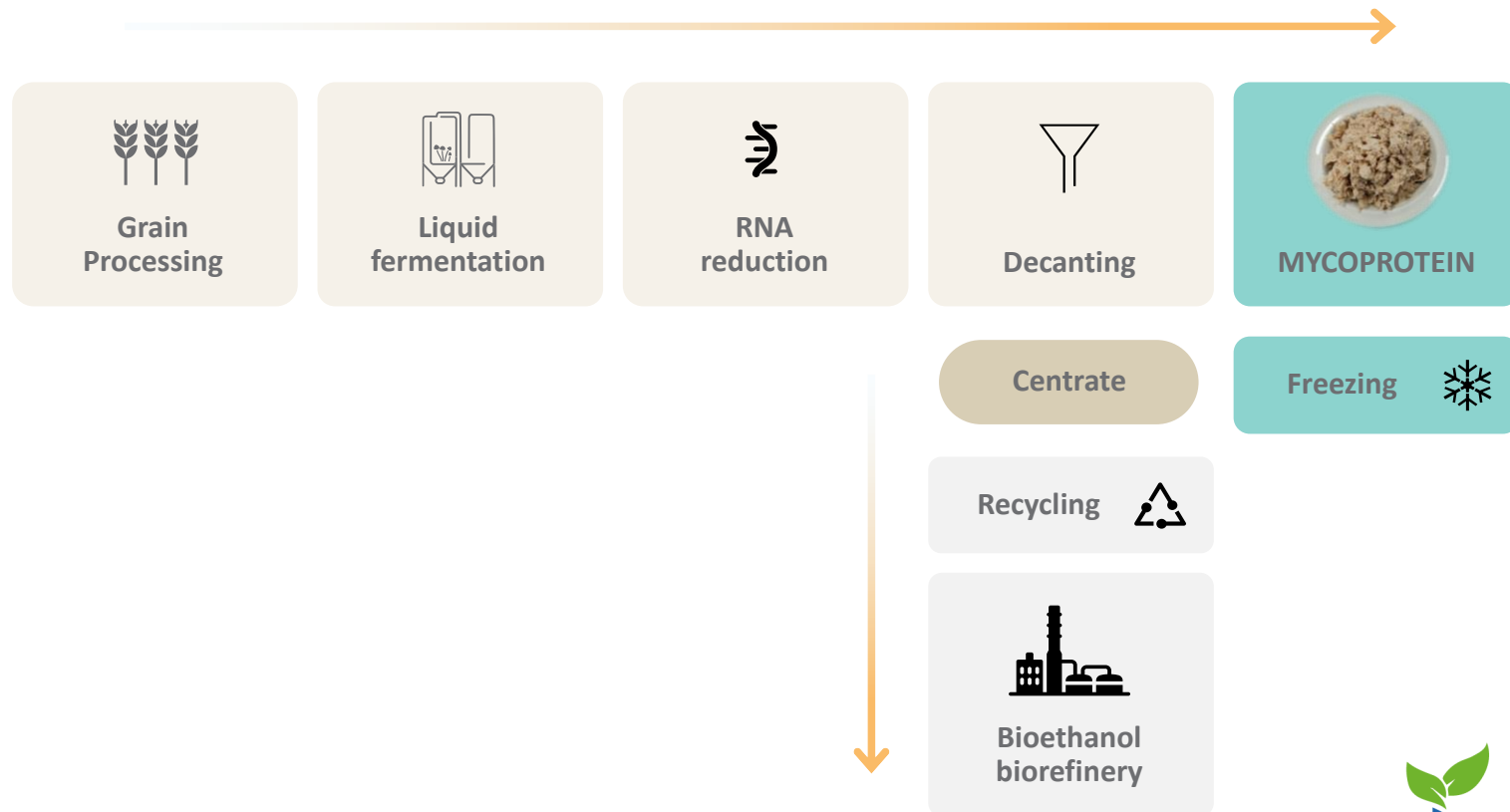


A team of 70, spanning 18 nationalities in 3 locations. HQ in Glasgow, Commercial team in London and main Operational site, co-located with Cargill, Sas van Gent.

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Mycoprotein Production

ENOUGH[®]




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Building a Sustainable Protein Future

CBE JU Flagship Program

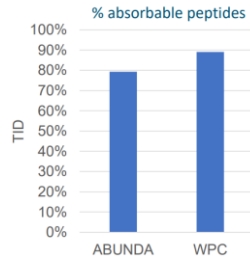
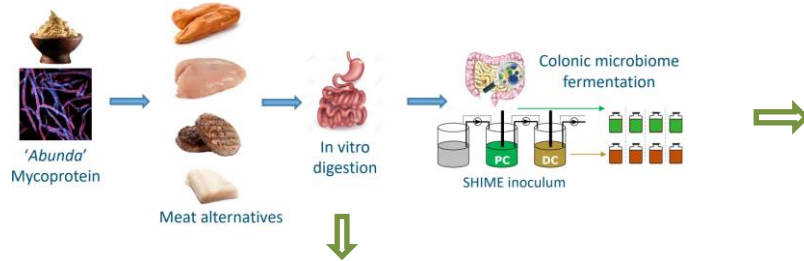
First-of-its-kind, large scale, minimal waste protein production
from renewable feedstocks



Plenitude has received funding from the Bio-based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No. 838104. The JU receives support from the European Union's Horizon 2020 research and innovation programme and the Bio-based Industries Consortium.

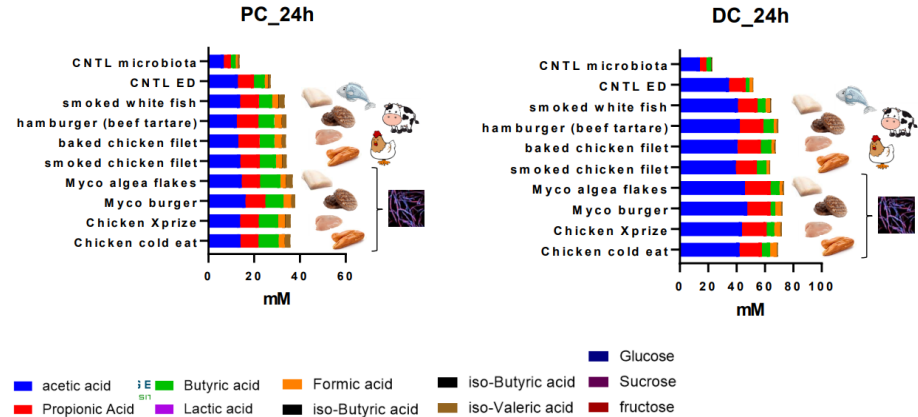
Digestibility

Digestibility of mycoprotein



Conclusions:

- TID of ABUNDA
 - Around 80% of peptides would be bio-accessible.
- Colonic microbiome fermentation
 - No major differences in microbial scFA production at t=6, 24 and 48 hours between mycoprotein products and meat counterparts



Effect of freezing on mycoprotein

Mycoprotein undergoes textural changes during freezing and frozen storage

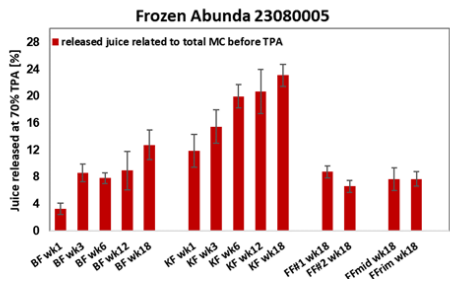
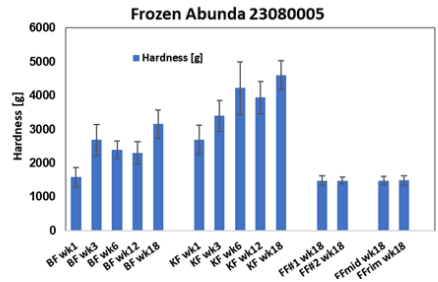
Materials:



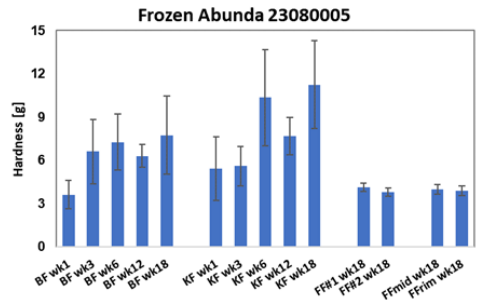
Fresh MP
(production date 11/8/2023?)



1. TPA tests:



2. Cutting tests:



Extrusion of mycoprotein blends

Mycoprotein texture altered through extrusion

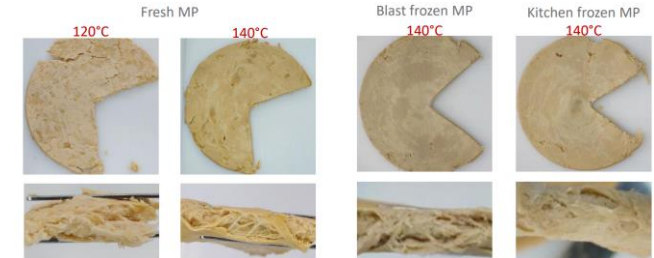
➤ High moisture extrusion



➤ Low moisture extrusion



➤ Shearcell



Microbiological aspects

Microbial safety, spoilage, and flavor changes in mycoprotein under different thermal treatments and packaging

- *L. monocytogenes* growth was slightly inhibited by 30% CO₂ in the package.
- At 4 °C in vacuum, *L. monocytogenes* increased by 2 logs within 7.5 days.
- 30% CO₂ prevented *B. cereus* outgrowth at temperatures ≤10 °C.
- Spoilage microbiota was dominated by genera *Pseudomonas* and *Paenibacillus*.
- Heating caused an increase of Strecker aldehydes and furans in the aroma profile.

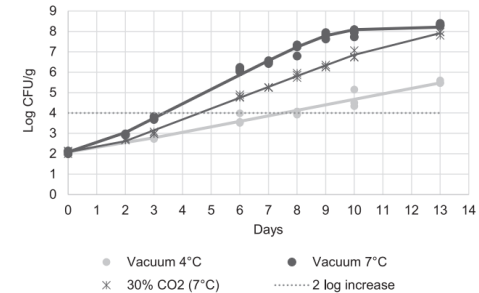


Fig. 1. *Listeria monocytogenes* growth on mycoprotein. Growth data are fit with logistic model.



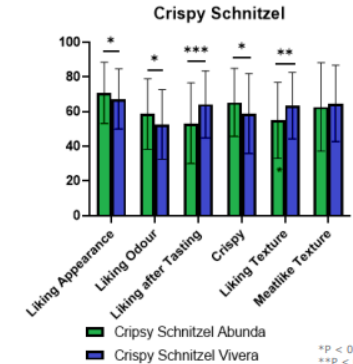
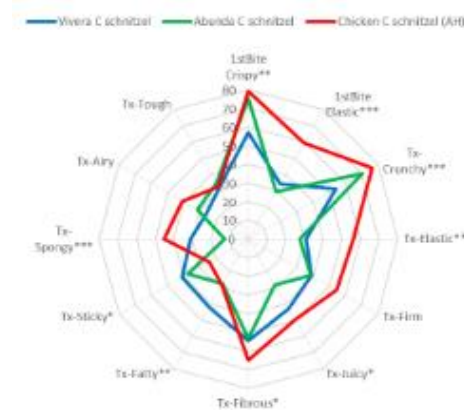
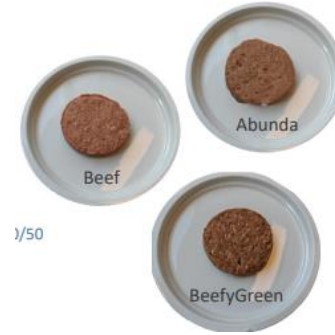
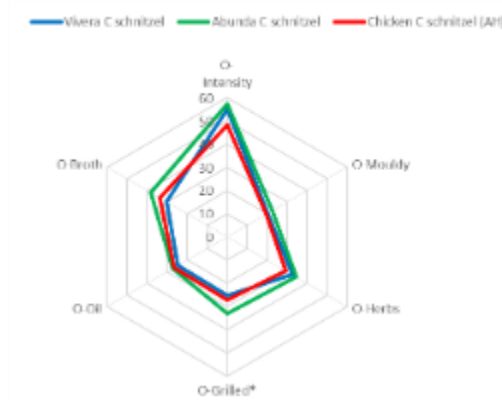
Microbial safety, spoilage, and flavor changes in mycoprotein under different thermal treatments and packaging

Hermien van Bokhorst-van de Veen, Eirini Pegiou, Lijiao Kan, Catrienus de Jong, Hasmik Hayrapetyan

Wageningen Food & Biobased Research, Wageningen University & Research, P.O. Box 17, 6700 AA Wageningen, the Netherlands

Sensory aspects of mycoprotein-based products

- Profiling study and consumer studies
- Schnitzels and hybrid burgers



Co-developement



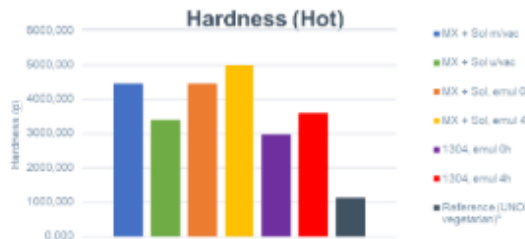
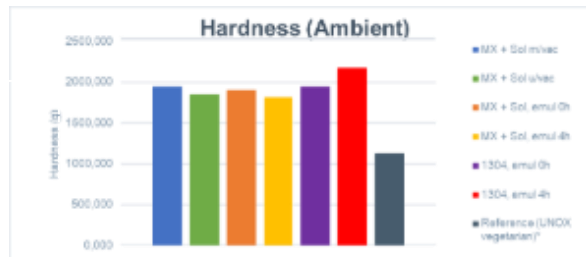
- Canned Hotdogs
- Canned SPAM/Luncheon Meat
- Ambient Packed Smoked Sausage/Rookwurst



Developed sample



Reference sample



Developed sample



Reference sample (meat)

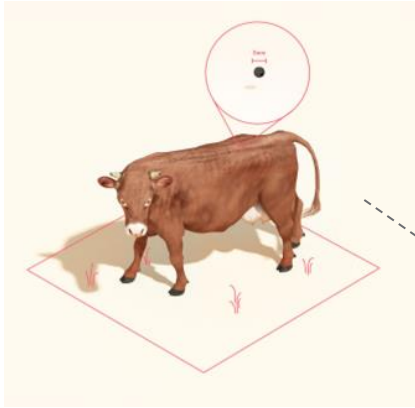


Reference sample (veg.)



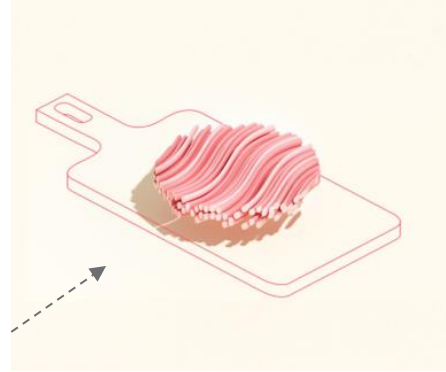
Bioprocess behind cultivated meat

Muscular biopsy from
a cow



Animal-free
proliferation of cells in
aggregates

Differentiation to fat
and/or muscle



... et voilà!

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Key findings

Textural improvements:

- Rheological analysis showed that the addition of aggregates to mycoprotein has the potential to simulate heat-induced behaviour of products better.

Flavour improvement:

- Abunda mycoprotein supports the suppression of soy and pea off-flavours. Cultivated material has a similar impact in a clean product. Therefore, combining the two allowed for ABUNDA to neutralise the plant base and the cultivated ingredients' taste to be highlighted.
- From a GC-MS analysis, it was observed that the aroma profile of ABUNDA is significantly different from that of cultivated ingredients. Abunda produces more Maillard products, which can complement beef aromas from Mosa Meat's material.

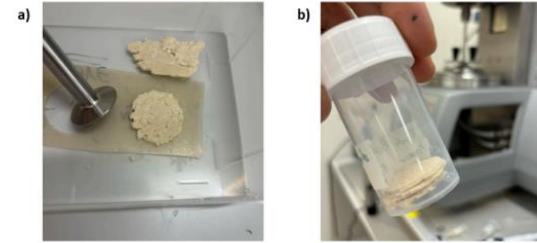
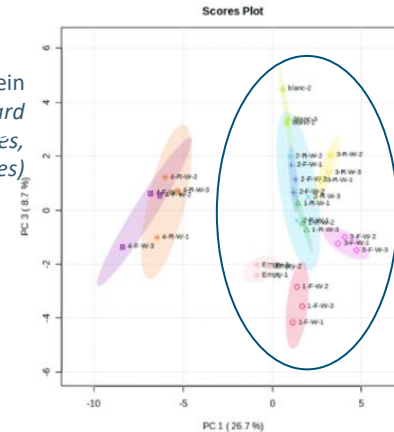


Figure 1: Preparation method of rheology samples by shaping the mycoprotein by pressing with a parallel plate geometry in a hole within a silicon mold.

Mycoprotein
Develops more Maillard
products (pyrazines,
terpenes and ketones)



Various cultivated
ingredients

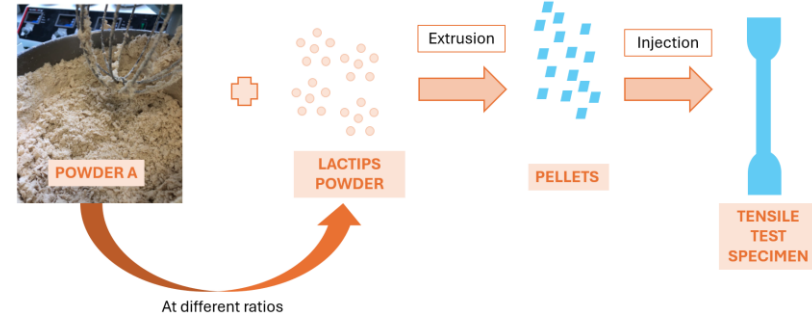
Bio-materials



Lactips - develops, produces, and sells the only industrial plastic-free polymer (casein). Based in France, SAINT-PAUL-EN-JAREZ.

Results

- It is possible to make bioplastic with ABUNDA with inclusion up to 75%.
- Mycoprotein addition modifies the textural properties of the specimen.
- The wet form of mycoprotein makes it difficult to process.
- Mixing it again with powder resulted in a homogeneous powder that was dosed easily. The more ABUNDA: Soy Protein mix in the powder, the more fibrous bits in the powder.



POWDER A was mixed with POWDER B at different ratios, see *Table 1* below :

Table 1 : Powder ratios

Samples	POWDER A : LACTIPS POWDER	ABUNDA inclusion
1	25:75	8%
2	50:50	15%
3	75:25	23%



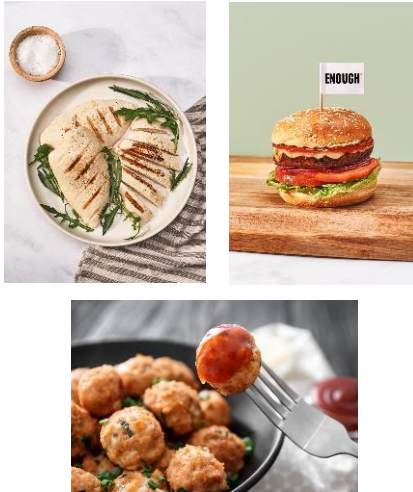
Figure 3 : Picture of tensile tests specimen

ABUNDA is a highly versatile alternative protein ingredient, which can be used in many different applications.

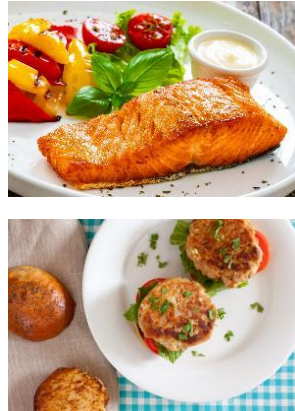
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Categories in focus

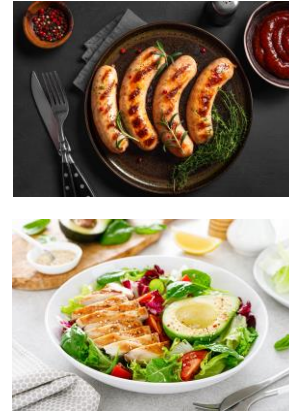
Meat Alternatives



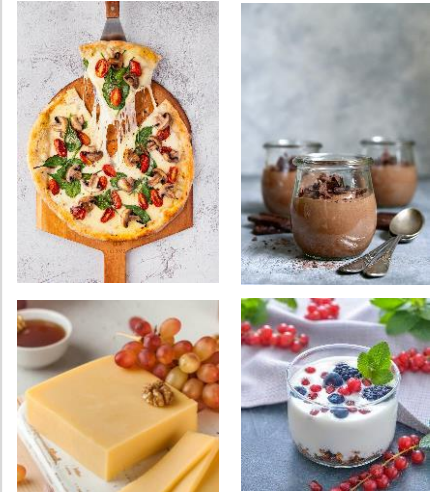
Seafood Alternatives



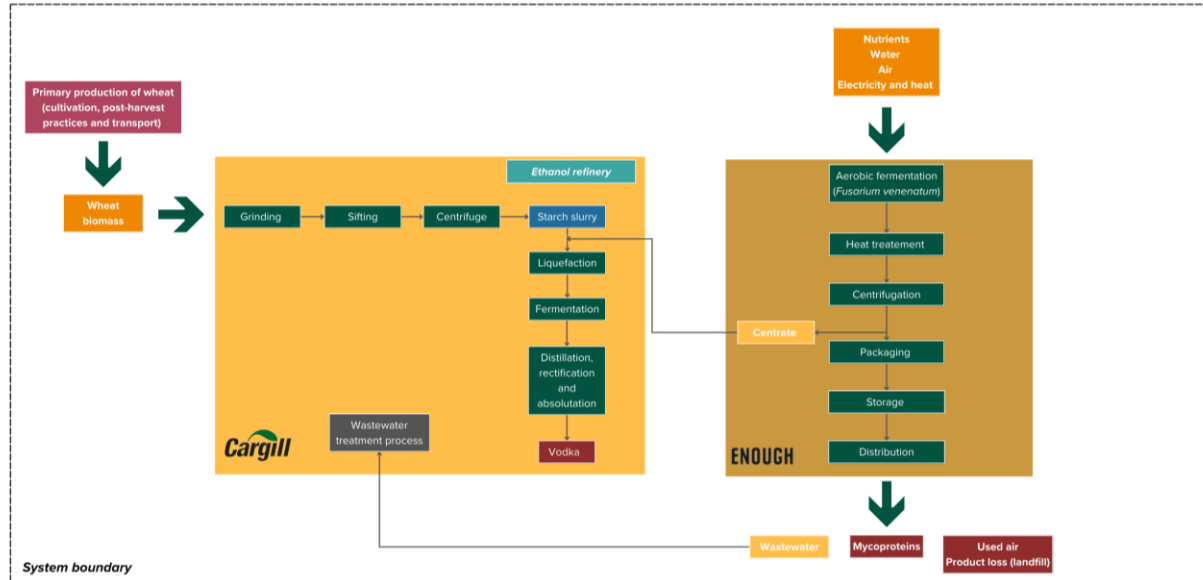
Hybrids



Dairy alternatives



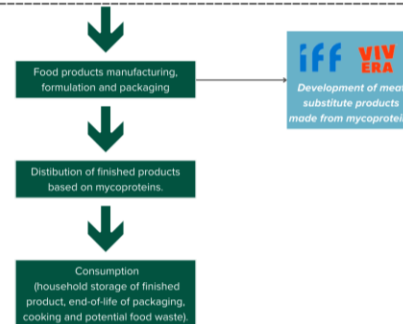
LCA – considered system boundaries



Flowchart illustrating the baseline scenario analyzed in this study.

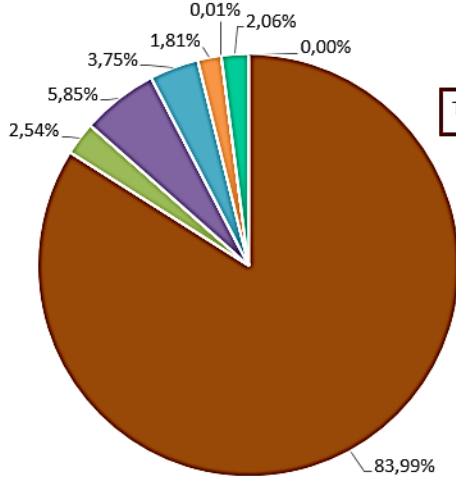
➤ Environmental impact indicators considered :

- **Climate change GWP** [kg CO₂ eq.]
- **Eutrophication** [kg P eq. / kg N eq. / mol N eq.]
- **Acidification** [mol H⁺ eq.]
- **Water use** [m³]
- **Land use** [Pt]



Use of mycoprotein in alternative-meat products

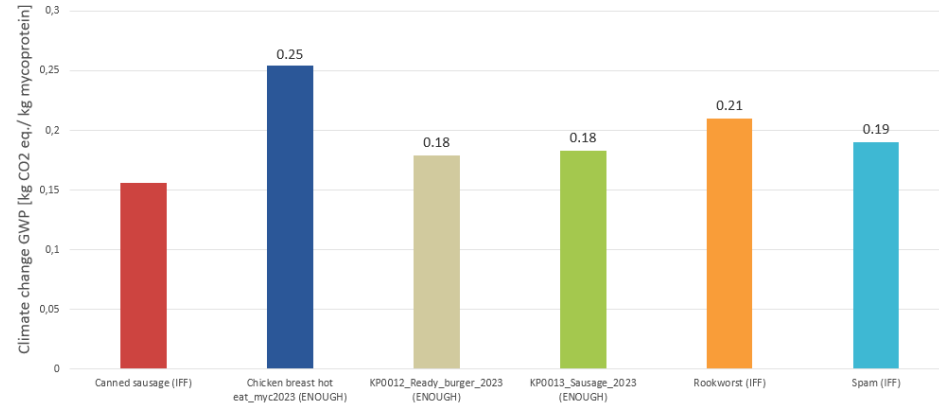
ENOUGH's Chicken breast recipe - climate change GWP [kg CO2 eq.] results



Total : 2.82 kg CO2 eq./ kg product



Comparative LCA analysis
Climate change GWP results [kg CO2 eq.]



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Thank you for your attention!

Questions?

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