CO FRESH

Tempeh based on Dutch Faba Beans

Innovation 3 of CO-FRESH/FOODVALLEY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000852

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Foodvalley
Shaping the Future of Food

CNTA

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Innovation: Development of a new product with faba beans from the Netherlands: Fermented meat alternative product (Tempeh) with a Better product recognition and marketing concept

Technology: Fermentation

Rational: Diversification of the use of Dutch Faba Beans

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Pilot case FOOD VALLEY NL

Foodvalley NL is the independent platform for innovation and transition of the global food system and focusses on three innovation fields: Protein Shift, Circular Agrifood and Food & Health.

Foodvalley NL has over 100 partners within the plant-based protein field covering the value chain from post-harvest to end product producers.

FoodvalleyNL, **THE NETHERLANDS.**
Support partner: WU.

The Foodvalley pilot case: from faba bean to meat analogue
Faba beans have the potential to become a winning green protein since Faba beans

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Why Tempeh?

- EU consumers are more and more familiar with **TEMPEH:** an Indonesian fermented food made from soybeans
- Soya TEMPEH is a great replacement for animal protein because it also has great nutritional value. It provides complete protein, containing full range of amino acids.
- Moreover, TEMPEH is also low fat, high in fibre, and provides significant amounts of iron, calcium, vitamin A, B- complex, and other nutrients.

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Why Dutch Faba Beans?

- Around 25 years ago, **legume crops almost disappeared from Dutch fields**.
- **The risks of soy dependence:** The Netherlands is dependent on imports for roughly 80% of its vegetable protein, and is the largest importer of soybeans in the EU.
- **Dutch government** is working towards circular agriculture and more production of local raw materials.

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Why the Fermentation Technology?

- To push fermentation process of TEMPEH, a fungus starter must be inoculated (e.g. *Rhizopus Oligosporus* and *Rhizopus Oryzae)*.

Benefits of this fermentation process:

- Along the fermentation process, the fungus produces a fluffy, white mycelia, binding the beans together to create an edible "cake" of partly catabolized soybeans. This fungus also has a proteolytic activity.

- TEMPEH starter culture *Rhizopus Oligosporus* can protect TEMPEH from infection bacterial and aflatoxins from the others fungus.

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Faba bean ingredients

Faba beans flour

Crushed faba beans

Faba beans

Faba beans

Nutritional Value (100 grams)	
Moisture (grams)	10.1
Saturated Fatty Acids (grams)	0.16
Unsaturated Fatty Acids (grams)	0.70
Total Carbohydrates (grams)	30.4
Total sugars (grams)	2.5
Dietary Fiber (grams)	27.7
Minerals (grams)	3.1
Protein (grams)	27.8
Salt (grams)	0
Energy (Kcal)	296

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Process development

Fermentation substrate

Overnight soaking in cold water

Remove soaking water, add clean water and boil

Drain the excess water and spread the beans on a tray to remove the husk.

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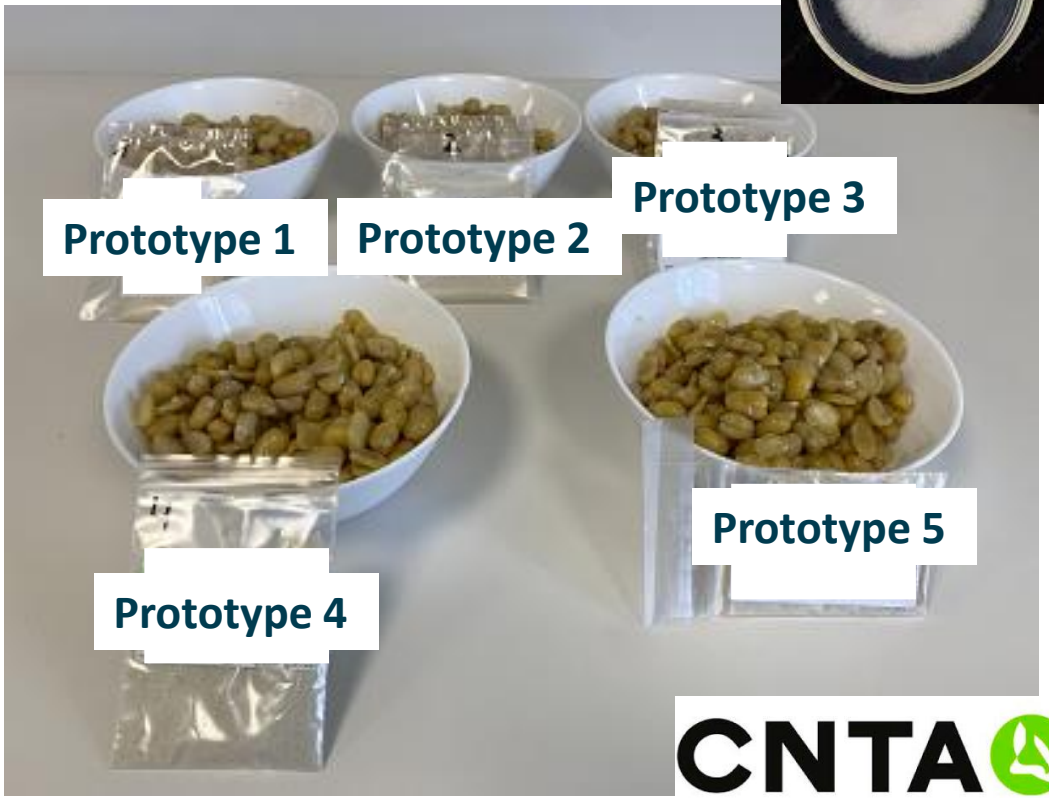
Process development

Add vinegar

5 Strains of *Rhizopus spp.* tested

Starter inoculation



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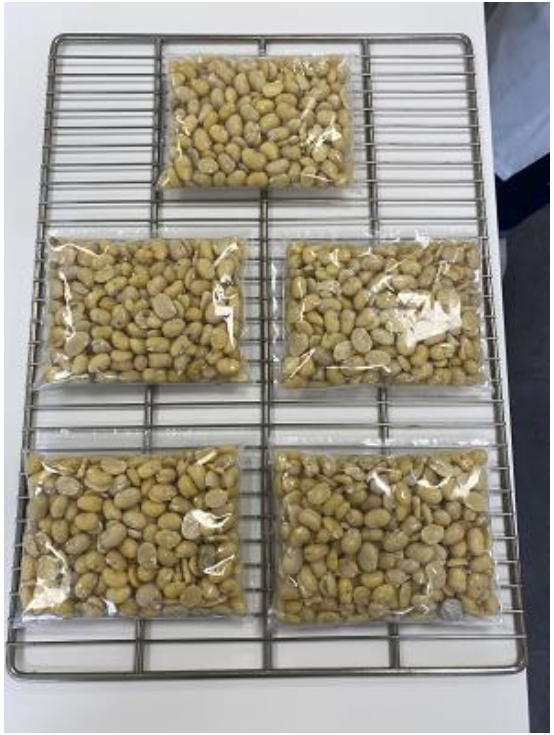
CNTA

Procedure (steps at the CNTA kitchen)



Incubation at 29-32 ºC
for 48 hours.

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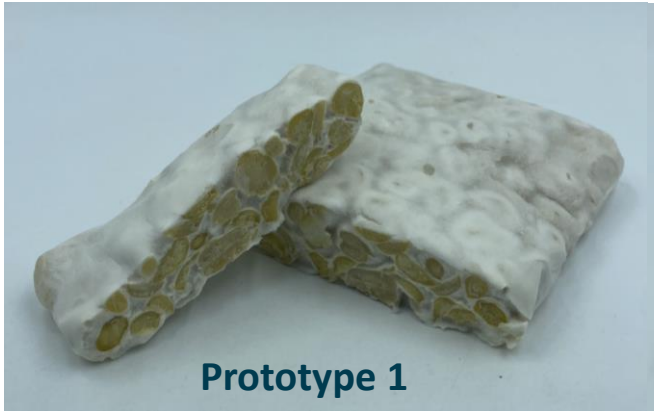
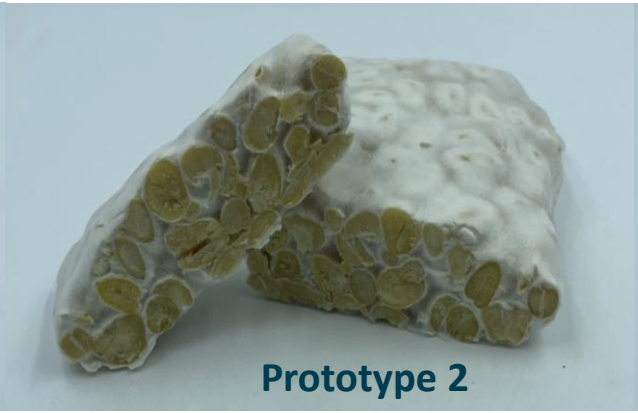
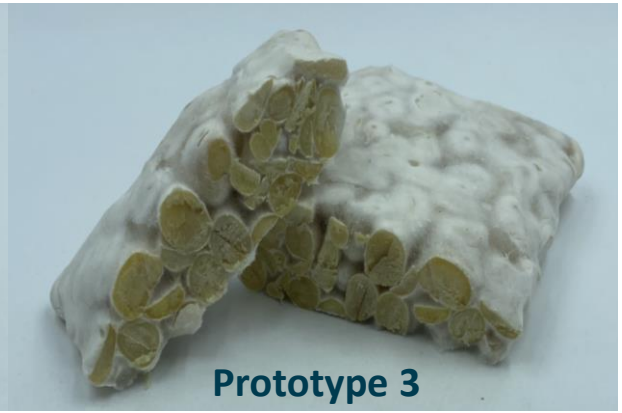
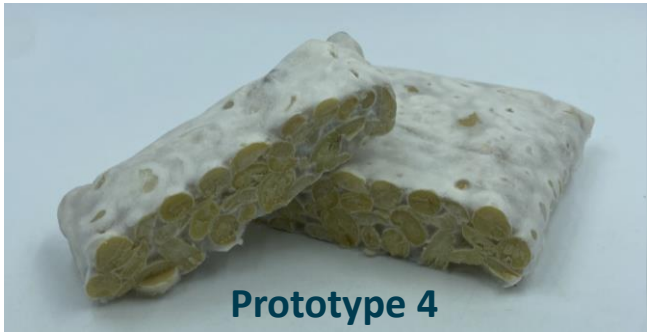
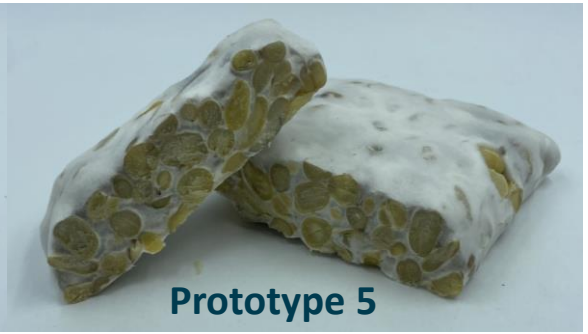
Preliminary Results











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Preliminary Results

Sensory Analysis

		Prototype 1	Prototype 2	Prototype 3	Prototype 4	Prototype 5
Sensory attributes	*Odor*	Acid	Low acid	Acid	Low acid	Nice odour (like mushroom)
	Hardness	Medium	Medium	Low	High	Medium
	Inner colour	Yellow-Brown	Yellow-Brown	Yellow-Brown	Light yellow	Brownish colour
	Outer colour	Off-white colour	Off-white colour	Off-white colour	Off-white colour	Off-white colour
	"bald spots"	Without bald spots	Without bald spots	Few bald spots	Few bald spots	Many bald spots
	Mycelium coverage	High	High	Medium	Medium	Low

according to the sensory evaluation, prototypes 4 and 5 would be discarded.

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Preliminary Results

Protein Content: Dutch Faba beans vs. Soya beans

Faba bean (Foodvalley)
28 g/100 g of protein

Commercial soy bean
37 g/100 g of protein

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Preliminary Results

Aminoacid profile: Dutch Faba beans vs. Soya beans

Faba bean contains lower concentration of all the aminoacids in comparison to soy bean.

	Concentration (g/100 g)	
	Faba bean	Soy bean
Trypthophan *	0,220 ± 0,022	0,525 ± 0,053
Cysteine+cystine	0,287 ± 0,040	0,547 ± 0,077
Methionine*	0,162 ± 0,023	0,442 ± 0,062
Alanine	0,947 ± 0,133	1,56 ± 0,22
Arginine	1,95 ± 0,27	2,72 ± 0,38
Aspartic acid	2,50 ± 0,35	4,22 ± 0,59
Glutamic acid	3,86 ± 0,54	6,98 ± 0,98
Glycine	0,989 ± 0,138	1,58 ± 0,22
Histidine*	0,605 ± 0,085	0,954 ± 0,134
Hydroxiproline	<0,2 (LOQ)	<0,2 (LOQ)
Isoleucine*	0,912 ± 0,128	1,65 ± 0,23
Leucine*	1,66 ± 0,23	2,86 ± 0,40
Lysine*	1,58 ± 0,22	2,38 ± 0,33
Ornitine	<0,05 (LOQ)	<0,05 (LOQ)
Phenylalanine*	0,969 ± 0,136	1,88 ± 0,26
Proline	0,962 ± 0,135	1,92 ± 0,27
Serine	1,11 ± 0,16	1,93 ± 0,27
Threonine*	0,851 ± 0,119	1,43 ± 0,20
Tyrosine*	0,752 ± 0,105	1,25 ± 0,18
Valine*	1,06 ± 0,15	1,69 ± 0,24

(*) Essential amino acids

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Preliminary Results

AminoAcid Score (AAS): Dutch Faba beans vs. Soya beans

		Faba bean		Soy bean	
Amino acid	Amino acid requirement (mg/g protein)	Amino acid (mg/g protein)	AAS	Amino acid (mg/g protein)	AAS
Tryp	6,6	7,9	1,2	14,2	2,1
Met + Cys	23	16,2	0,7	26,7	1,2
His	16	21,8	1,4	25,7	1,6
IsoLeu	30	32,8	1,1	44,5	1,5
Leu	61	59,7	0,98	77,2	1,3
Lys	48	56,8	1,2	64,2	1,3
Tre	25	30,6	1,2	38,6	1,5
Val	40	38,1	0,95	45,6	1,1
Phe+Tyr+Tryp	41	69,8	1,7	98,6	2,4

Faba beans is first-limiting in sulphur amino acids (methionine-cystein) with an AAS of 0,7. Leucine and Valine are also limiting amino acids.

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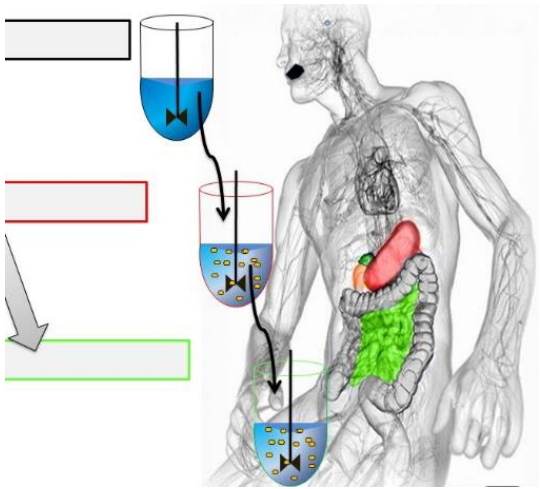
Preliminary Results

Digestibility: Dutch Faba beans vs. Soya beans



Protein	Protein digestibility (%)
Faba bean	**64,7 ± 9,69**
Soy bean	49,9 ± 5,9

- ***In vitro* protein digestibility of faba bean is greater than the digestibility of soy bean.**

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Standardised static in vitro digestion method proposed by *Minekus et al.* (2014)

Preliminary Results

IVPDCAAS: Dutch Faba beans vs. Soya beans

Protein	IVPDCAAS
Faba bean	*45*
Soy bean	*56*

- **Faba bean shows lower PDCAAS than soy bean due to the low content of sulphur amino acids.**
- **However, its in vitro protein digestibility was greater than soy bean.**

PDCAAS in different vegetable proteins

TABLE 1 PDCAAS values for pulses and select cereal grains

	AMINO ACID SCORE[1]	TRUE PROTEIN DIGESTIBILITY[2] (%)	PDCAAS[3]
Pea *(yellow, split)*	0.73	87.9	0.64
Pea *(green, split)*	0.59	85.2	0.50
Lentil *(green, whole)*	0.71	87.9	0.63
Lentil *(red, split)*	0.59	90.6	0.54
Chickpeas *(Kabuli)*	0.61	85.0	0.52
Pinto Beans	0.77	76.2	0.59
Kidney Beans	0.70	78.6	0.55
Black Beans	0.76	70.0	0.53
Navy Beans	0.83	80.0	0.67
Wheat Flour[4]	0.47	92.3	0.43
Rice Flour[4]	0.54	92.0	0.50
Soy Flour *(50% protein)*	0.92	83.5	0.77
Pea Protein Isolate *(82% protein)*	0.54	97.1	0.53
Pea Protein Concentrate *(50% protein)*	0.58	92.6	0.54
Soy Protein Isolate *(93% protein)*[5]	0.87	96.0	0.84
Casein	1.04	96.6	1.00

[1] *Amino acid score is the limiting amino acid with the lowest ratio relative to the established amino acid requirement values for humans, aged 2 to 5 years old.*
[2] *AOAC method 991.29 (n=10)*
[3] *PDCAAS = Amino Acid Score x % True Protein Digestibility*
[4] *Data for wheat and rice flour obtained from the 1989 WHO/FAO Expert Consultation on Protein Quality Evaluation. All other PDCAAS values obtained from independent studies for Pulse Canada (House et al, 2011, 2014).*
[5] *Sarwar, G. 1997 J. Nutr. 127:758-764.*

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Next steps

- Conclude Formulation and Process development:
  - Digestibility test on Tempeh: to check impact of fermentation on protein digestibility
  - Production process optimization & packaging definition
  - Shelf-life studies, nutritional and sensorial profile of selected protypes
  - Technoeconomic assessment
- Brand & Product image development (on going)

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Standardised static in vitro digestion method proposed by *Minekus et al.* (2014)

Tempeh can be an excellent way to incorporate the nutritional benefits of faba beans into our diet.

Tempeh fried in olive oil on lettuce sprouts accompanied by soy sauce

Tempeh fried in olive oil over rice with vegetables and soy sauce

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