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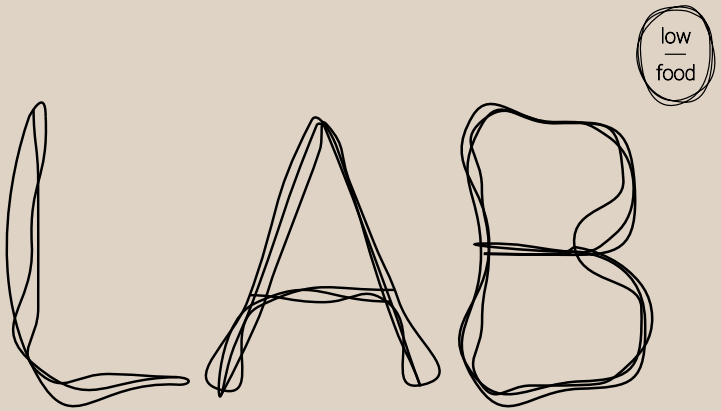
Low Food Lab:

Water lentils



About Low Food Lab

Low Food Lab is a pilot for an open source platform in the Netherlands that investigates how gastronomy and culinary techniques can offer solutions to societal challenges in our food system. With Low Food Lab, we explore the potential of new, forgotten, not yet explored, undervalued products in the Netherlands. Previously, Low Food Lab looked into Grains. At the moment, Broth and Okara have the Lab's attention. Visit **www.lowfood.nl** for more information.

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How to eat... duckweed?
An exploration of innovative recipes

Introduction by Samuel Levie

Tapping into new and alternative sources of protein* has been on the agenda for years when it comes to human consumption, as experts consider it unsustainable for a growing population to maintain its current, meat heavy diet. Experiments often include seaweed and algae-farming, in open sea as well as in large bassins, but also growing locust and larvae, to name but a few examples. These sources seem alien to us, while they are part and parcel of other cultures' menus. During culinary research in our home country, we came across a funny, little, floating plant. Apparently, this is the world's smallest, blossoming plant, and very rich in terms of protein and other nutrients: duckweed! Even though water lentils (our preferred name for duckweed) is not marketed for human consumption as of yet, due to food safety regulations, we took a chance and moved forward.

Together with chef Emile van der Staak (De Nieuwe Winkel, Nijmegen) and food scientist Bart Smit (Smaakpark, Ede) we took a close look at this miniscule plant and its culinary potential. How does it respond to a range of lacto and fungal fermentations? Officially,

water lentils are not yet recognized as safe for human consumption by the European Food Safety Authority. But with this publication, we aim to inspire you with a new set of recipes. Not only to use water lentils in the future, but also to inspire you to explore and experiment with other alternative sources of protein and their culinary applications.

***PROTEIN TRANSITION**

Why are we interested in 'alternative' sources of protein? Research shows that animal based products (meat, dairy) will not be a sustainable nor sufficient source of protein for our future human population. For more information, see: https://www.wur.nl/nl/show/Dossier-Eiwittransitie.htm

About Low Food Lab: Water lentils

Water lentils is a collective name for tiny, bright green, aquatic plants from the Lemna family, commonly known as duckweed. Interestingly, they happen to be extremely rich in protein. In that regard, one hectare of water lentils equals ten hectares of soy[1] in terms of protein. For that reason, water lentils caught the attention of experts involved with the protein transition. The application of water lentils is currently explored.

1 – https://edepot.wur.nl/522334

However, due to its unusual taste, unprocessed water lentils are not suitable for dishes, except for low concentrations (see examples of low-concentration-use in this **cookbook**). In search of ways to unlock the protein potential of water lentils, researchers started to "refine" them. This is a labor intensive, multi-step process that works to extract actual ingredients from fresh water lentils. This results, for instance, in a powder and gel that can have a variety of applications in turn, such as beverages (see **rubiscofoods.com**). A disadvantage of this process is that it produces residual flows, one of them being the bits and parts of water lentils that are put to waste.

Institutional research, development and the 'novel food process'

Another challenge with regard to future use of water lentils is to successfully pass the novel food process. Water lentils are not accepted by the European Food Safety Authority (EFSA), for they are 'new' foods that have not passed the 'novel food process' as of yet.

Novel foods or novel food ingredients are foods that have no history of 'significant' consumption in the European Union prior to 15 may 1997. Any food that falls within this definition, must be authorised according to the Novel Food legislation, Regulation (EC) NO 258/97 of the European Parliament and of the Council. In order to be regarded as 'safe for human consumption', applicants must seek authorization through the EFSA.

The underlying principles underpinning Novel Food in the European Union are that Novel Foods must be 1) safe for consumers, 2) properly labelled, so as not to mislead consumers and 3) if novel food is posed as an alternative for an existing product (for example, soy milk as alternative to milk), it should meet the same nutritional standards. Currently, Wageningen Plant Research (whole crop and plant material) and Rubisco Foods (protein concentrate) filed an application for authorisation on the use of Lemna minor and Lemna gibba. They are currently awaiting the outcome of the risk assessment by the EFSA (expected result january 2022).

Researchers

Emile van der Staak

Emile van der Staak is chef and owner of Restaurant De Nieuwe Winkel and introduced botanical gastronomy in the Netherlands. De Nieuwe Winkel is awarded two Michelin stars, one of them being a green star celebrating sustainable practice. Emile preferably cooks with whatever nature supplies, and he is always looking for exciting new flavors. Fermentation plays an important role in his kitchen, both for conservation purposes and in developing unique flavors. Why not try and make something delicious out of water lentils? In this Low Food Lab, Emile figures out how to turn duckweed into something he would proudly present to his customers.

denieuwewinkel.com

Bart Smit

Bart Smit is a microbiologist and fermentation scientist fascinated by sustainable and healthy food. Under his own company name FerMentor, he works for food activity-centrum SmaakPark, NIZO, universities, food companies and many others. Since fermentation has no secrets for this scientist, Bart is the perfect co-laborant of this Low Food Lab.

fermentor.nl smaakpark.nl

Methods and results

Gastronomic research

The Low Food Lab researchers set out to find ways to work with the entire crop that enhance the culinary appreciation of water lentils. Put differently, through gastronomic research, they aim to develop new, crop-based recipes that enable and promote the use of this rich and abundant crop.

As the research is experimental, it was organized in three successive stages that first explore and then refine a couple of ideas and recipes, based on trial and error. In this case, Bart and Emile approached water lentils with their personal expertise, and drew from experiences with other crops. They evaluate how water lentils respond to different techniques in general, and fermentation in specific, as this is a new way of working with water lentils. To verify results, they used reference studies. Point of departure is 10 kilos of fresh water lentils in good condition, mainly *Lemna minor,* provided by **The Green East**.

The following parts discuss the road(s) taken that led Bart and Emile to successfully develop a water lentil based dish using fermentation techniques. We elaborate on the (fermentation) techniques used by Emile and Bart, as well as some general observations and lessons learned with regard to culinary application of water lentils.

(Lacto-)fermentation: yoghurt

To try the effect of fermentation, water lentils were processed in different ways. Variation was sought in terms of crop management; from whole crop to mousse and cooked mousse, and more importantly, in terms of added salt, sugar, soy, milk and a variety of starters*. The research learned that water lentils lack a sufficient amount of fermentable sugars as basis for fermentation to yoghurt-like products, as indicated by pH measurements and how they maintain their wry taste over incubation time. It is found that fermentation processes can be stimulated with added sugars, soy or milk. Yet, the results are disappointing in terms of flavours, which led the researchers to conclude this track.

*a starter, or inoculum, is a dose of micro-organisms that initiates the fermentation process.

Sauerkraut

As water lentils lack a suitable sugary basis for fermentation, they are mixed with cabbage and carrots. Varieties with cooked and uncooked lentils are produced, as well as a reference study. Although the samples acidified well, the unpleasant taste remained and its colour turned dull brownish-green.

A selection of additional bacteria might mitigate the taste effect (dull colour will remain), but this will require a major screening effort and is taking sauerkraut quite far from its natural origin. Alternatively, one could experiment with a limited amount of water lentils by reducing the lentil content in the recipe. For the final recipe the sauerkraut was made with 500g of water lentils, 900g of cabbage and 100g of carrots.

Drying

Drying the crops is pursued under pressure - between hot plates - as well as in the oven. The latter method delivered the best results in terms of remaining colour and structure. Nevertheless, drying is not further elaborated upon; Emile and Bart chose to focus on culinary applications that require less energy consuming processes. In addition, the products obtained through drying were very fragile, which limits their application.

Extracting chlorophyll

The researchers sought to extract chlorophyll from water lentils because green pigment is much wanted in the kitchen. Heating and filtering a water lentil mousse resulted in an extraordinary green suspension. Colour-wise very interesting, yet the wry taste and astringent sensation due to the (remaining) concentration of polyphenols, prohibits most applications.

Miso

Because of the watery character of these lentils, it is decided to develop miso rather than koji. A first try at miso is immediately successful: a good smell with hints of fruit and earth is obtained, and the product acidified well (pH below 4). Further attempts learn that water lentils make for a nice, unique and aromatic miso with clear reference to water lentils. Except for the salty variation, which did not ferment properly. The miso was made by mixing 2 parts of (cooked) lentils with 1 part of a koji based on wheat and *Aspergillus oryzae*.

Methods and results

Tempeh (burger)

A lentil mousse is mixed with uncooked bulgur, shaped into a burger, steamed to fix the structure, and inoculated with a tempeh-specific fungus, *Rhizopus*. Lemon was used to control pH-levels of the lentil mousse. Slightly different proportions, and using both fine and rough bulgur, made up four varieties, resulting in four different burgers. *Rhizopus* fungus developed well over 40 hours incubation, making for proper fermentation, and the burgers were appreciated for their savory/ mushroom taste and solid structure. Eventually the burgers were made with 120g of fine to medium fine bulgur together with 400g of water lentils.

General observations

Although water lentils are rich in protein, they score high on polyphenol-type compounds as well, which cause a strong, long lasting wry taste - a negative sensation indeed - which limits the culinary application of water lentils in some ways, but not others. Fermentation sure is a way to process water lentils in that respect. Although defined- and wild and lacto fermentation are not successful, mould cultures work very well!

Another challenge with regard to unlocking the protein potential of water lentils, is to get rid of the 'water', as the protein is situated in its dry matter. As long as water lentil dishes exist for the lion's share of water, the proteins are obviously highly 'diluted', so to say.* Although drying was tested shortly, this Low Food Lab focussed on culinary application of whole crops and did not aim to reproduce previous extracts (powder) from RubiscoFoods.

*Given that water lentil crops contain 5% dry matter, of which 20% is protein, using crops directly in your dishes means that you should calculate for 1% protein on wet weight

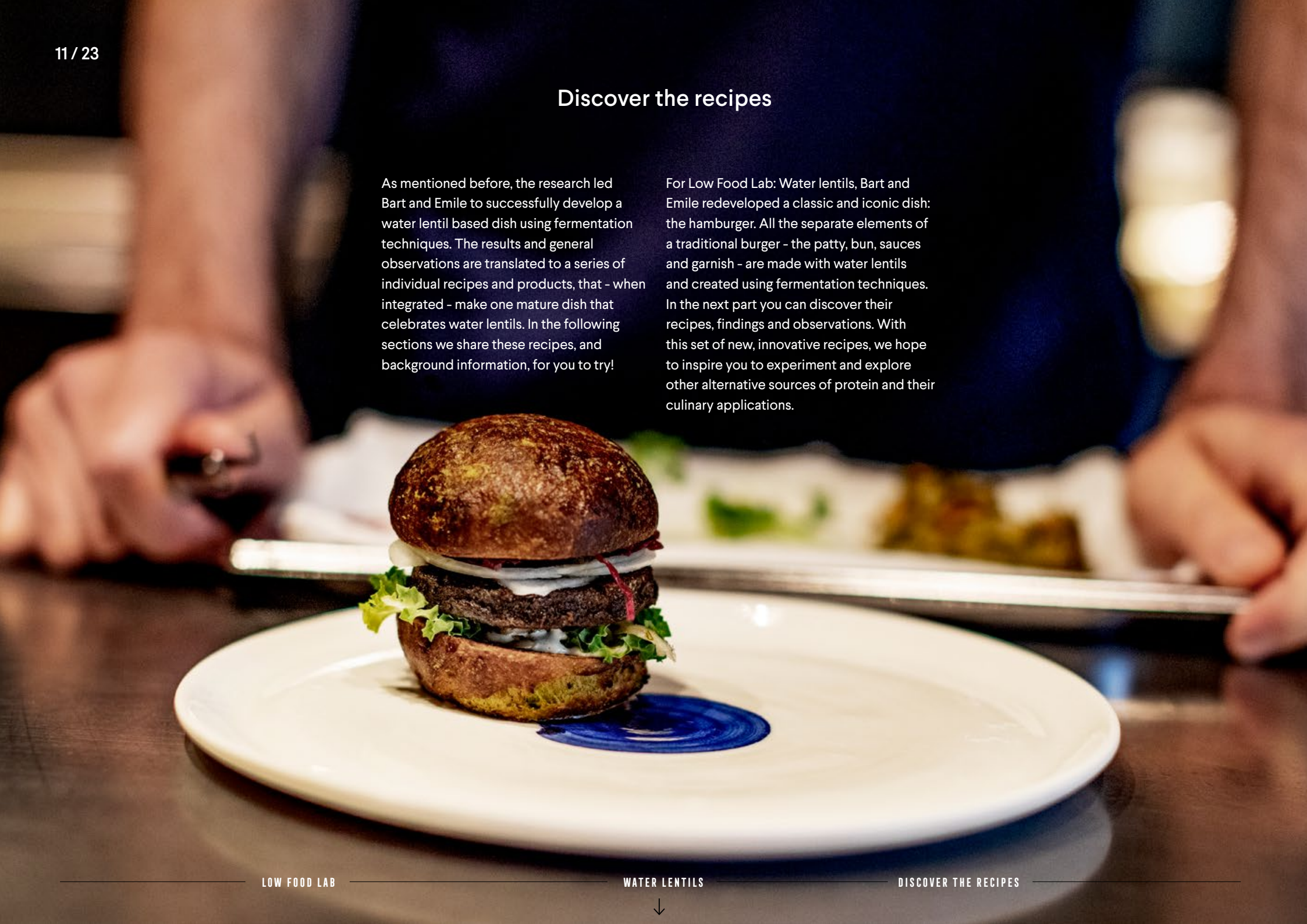
Lessons learned

- In yoghurt, by lacto-fermentation, the wry taste of polyphenol remains
- In sauerkraut, by lacto fermentation, the wry taste of polyphenol slightly decreased, but remained unacceptable - the final recipe used little water lentils compared to cabbage
- Miso, by *Aspergillus* based fermentation, works well and is rich in flavour
- Tempeh, by *Rhizopus* based fermentation, is produced easily and tastes well

Discover the recipes

As mentioned before, the research led Bart and Emile to successfully develop a water lentil based dish using fermentation techniques. The results and general observations are translated to a series of individual recipes and products, that - when integrated - make one mature dish that celebrates water lentils. In the following sections we share these recipes, and background information, for you to try!

For Low Food Lab: Water lentils, Bart and Emile redeveloped a classic and iconic dish: the hamburger. All the separate elements of a traditional burger - the patty, bun, sauces and garnish - are made with water lentils and created using fermentation techniques. In the next part you can discover their recipes, findings and observations. With this set of new, innovative recipes, we hope to inspire you to experiment and explore other alternative sources of protein and their culinary applications.



Tempeh burger

INGREDIENTS

- 400 g water lentils
- 120 g bulgur or couscous (fine to medium-fine)
- 1 tbsp vinegar
- Table salt
- Koji-starter (Aspergillus oryzae), diluted with ratio 1:5 or 1:10 in some maltodextrin, potato- or corn starch (enough to coat the burgers)
- 50 ml of dark beer (we used Gulpener Gladiator)
- 20 g of glucose
- 2 dried plums

MATERIALS AND EQUIPMENT

- Ring moulds Ø10-15 cm
- Perforated gastronorm tray
- Tea-strainer

DIRECTIONS

1. In a large bowl, mash water lentils together with vinegar and salt, until a smooth mixture forms (pH ±4,5).
2. Mix the lentil mousse with bulgur.
3. Place this mix in the ring moulds, fill them up to about 1-1,5 cm height, place on perforated gastronorm tray.
4. Steam until just done (ca. 15 minutes, 100 °C).
5. Cover the burgers to prevent evaporation, allow to cool down to 25-35°C.
6. Remove ring moulds.
7. With the use of a tea-strainer, evenly disperse the koji-starter mixture across the burgers and cover with a thin layer of powder all around.
8. Place the burgers on a raster of some sort, and store them in a bucket, covered with a wet tea towel. This is to facilitate them with oxygen, and prevent dehydration.
9. Incubate between 30-44 hours at 28°C, until the burgers are covered in a white layer of mould. When taking too long, the fungus will show green or black spots (depending on used strain). These are the new spores, which is less esthetic but not harmful.
10. Make a glaze from dark beer, glucose and plums, to cover the burgers after baking them.

ALTERNATIVES

- Use different wheat/grains
- Use different structures (fine-medium-coarse)
- Add herbs/spices

Learn more about water lentil-Tempeh

Miso-starter refers to a fungus named *Aspergillus oryzae.* This fungus grows fast and aerobically - meaning that it thrives on oxygen. It creates nice and compact mycelium (a network of fungal threads), and has a great capacity to break down plant materials. That is why *Aspergillus* is used for miso's koji, but applying this fungus for tempeh is new. If not interrupted, *Aspergillus* will consume so much of the proteins and starch, that it will result in a soft/weak texture to your burgers and make the taste intensive.

↓

Water lentil Miso

INGREDIENTS

- 500 g emmer wheat
- 2 g koji starter (available online)
- 600 g fresh water lentils
- 54 g of salt (sea- or table salt)

MATERIALS AND EQUIPMENT

- Vacuum bags (20x30 centimetres)

DIRECTIONS

To make miso with the water lentils, we first need to make koji:

1. Cook the emmer wheat al dente (~10 min), spread out on a perforated gastronorm tray, and allow to cool to at least 35°C.
2. Inoculate the wheat with a small amount of koji-starter, mix, and spread again. Then cover with a wet tea towel to prevent dehydration.
3. Incubate at 28-30 °C for 36-48 hours.
4. Stir the Koji after approximately 24-28 hours, to lift and air the wheat granules. Re-moisten the towel. Optional: Moisten the product with a clean plant sprayer, appearance should remain dry, while water should be available to the organism.

For the miso:

1. In a large bowl, mix the water lentil with 200 grams of your homemade koji and the salt
2. Blend shortly until smooth, or use a meat grinder.
3. Divide the mixture in the vacuum bags (~200 g/bag) and seal to close, but do not vacumate.
4. Incubate at 18-25 °C for 6-50 weeks. After 8-12 weeks the miso's fruity taste is at its best, and the product can be refrigerated to stop fermentation. Cut a tiny opening on the side of the bag to press out remaining air. After removing all the air, re-seal the bag and vacuum airtight.
5. Miso can be preserved lengthy, although its character might change over time, as the chemical processes slowly continues.

ALTERNATIVES

- Vary with the fungal strain.
- Vary with the amount of salt and recipe. More salt will lead to an earthy, less fruity Miso. Don't go below 6% considering food safety.

Learn more about Miso

Miso is a proper seasoner, and despite the low concentrations that miso is normally used in, water lentils do surface the taste. Water lentil-miso brings about a complex bouquet similar to traditional wheat-miso, yet the water lentil specific tones are apparent, without its dominant wry component, which is probably consumed by the fungus.

Good to know: in this recipe, a common koji-starter is used, with the family name *Aspergillus oryzae.* However, the genetic variation *within* microbiology-families is huge, exceeding differences between a human and a pig! That is why family-members of starters and spores are often indicated with a code (letters or numbers), or given commercial names. This happened for example to the yoghurt probioticum that is very well known as *Lactobacillus rhamnosus*, which is named LGG. LGG offspring are identical while there are thousands of *Lactobacillus rhamnosus* strains. The family of lactobacilli was actually so diverse that recently this family has been split into new families, with new names. The new name for *Lactobacillus rhamnosus* is *Lacticaseibacillus rhamnosus.* Knowing this background on diversity, it is worthwhile to buy "the same" *Aspergillus* from another supplier, because chances are that you get a different strain - which can lead to a different end result.

Sauces

Water lentil miso-mayonaise

INGREDIENTS

- 100 g egg yolk
- 15 g mustard
- 7 g salt
- 30 ml vinegar
- 500 ml oil
- 200 g water lentil-miso

MATERIALS AND EQUIPMENT

- Blender

DIRECTIONS

1. Add all ingredients to a blender, except for the oil.
2. Add the oil drop-by-drop, while the blender works the emulsion.

Water lentil-ketchup

INGREDIENTS

- 60 g onion, chopped coarsely
- 40 g fennel, chopped coarsely
- 2 cloves garlic
- 6 g coriander seed
- 600 g green tomato
- 400 g water lentils
- 200 ml apple vinegar
- 70 g sugar

MATERIALS AND EQUIPMENT

- Blender or food processor
- Sieve

DIRECTIONS

1. Add fennel, onion, coriander seed, garlic, salt and pepper to a pan.
2. Slow-cook for 15 minutes, until soft.
3. Add tomatoes and water lentils.
4. Bring to cook and boil down to half the volume.
5. Blend in a kitchen machine and pass through a fine meshed sieve to make smooth.
6. Put back in a pan and add vinegar and sugar.
7. Boil down to desired consistency.
8. Flavor with pepper and salt.

ALTERNATIVES

- Vary with the baseline of the sauces

Water lentil sauerkraut

INGREDIENTS

- 500 g water lentils
- 900 g organic white cabbage
- 100 g organic carrot
- 30 g salt

MATERIALS AND EQUIPMENT

- Mandoline slicer

DIRECTIONS

1. Use a mandoline slicer (or by hand) to cut the cabbage in thin strips.
2. Use a mandolin slicer (or by hand) to cut the carrot julienne and mix with cabbage.
3. In a large bowl, mix water lentils, salt, cabbage and carrot.
4. Put in vacuum bags and seal airtight.
5. Incubate at 20 °C for 5-15 days.
6. Check for gas (CO_2) daily, if needed, perforate the bag with a small* outlet to relieve pressure.

**When the hole is small, O_2 is unlikely to enter the bag, and chances for undesired fungal growth stay minimal.*

ALTERNATIVES

- Flavor with herbs. Other than cloves, bay leaf, cumin and perhaps some pepper, you could think of warm and sweet flavors. This might mitigate the wry taste of water lentils. However, in this example recipe we did choose to stay close to a natural sauerkraut.

Learn more about sauerkraut
Sauerkraut is a textbook example of a spontaneous fermentation instigated by lactic acid bacteria which naturally occur on these plants. Therefore, it is important to not wash the cabbage, nor cut too much of its outer leaves. By using a considerable amount of cabbage and some other crops (cold earth grown carrots), you are sure to have enough bacteria to start fermentation. That is, because we do not know exactly what bacteria inhabit an aquatic system, and whether these are equipped to create a nice tasting ferment. That is why combining crops is the smart thing to do here.

Water lentil brioche

INGREDIENTS

- 500 g flour
- 25 g sugar
- 7 g salt
- 175 g butter
- 25 g fresh yeast
- 60 g egg yolk
- 75 g milk
- 120 g water lentil juice from a slowjuicer

MATERIALS AND EQUIPMENT

- Stand- or planetary mixer with dough hook
- Steam-oven
- Slowjuicer

DIRECTIONS

1. Put all ingredients in the bowl of the mixer.
2. Mix 2 minutes at slow pace.
3. Mix 5 minutes at fast pace.
4. Weigh out pieces of (40 grams) and shape into balls.
5. Steam-bake 4 minutes at 220 °C with 40% steam.
6. Lower temperature to 205°C with 20% steam and bake for an additional 5 minutes.
7. Brush with melted butter when they come from the oven.

ALTERNATIVES

The dough is low in water lentil juice, which leaves room for other options, flavor wise. Pick your flavors, herbs and make combinations.

Learn more about brioche
Brioche is a small-sized, soft, round and rich bread, and the perfect base to carry the strong taste of water lentil. Try and experience for yourself! To not disrupt the soft structure of brioche, this recipe worked with water lentil juice from a slowjuicer.

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"The Low Food Movement has set the goal to change Dutch gastronomy. The Low Food Movement was founded by Joris Lohman, Joris Bijdendijk and Samuel Levie in 2018. The movement since then has grown and the goal is to change Dutch Gastronomy and to make Dutch food culture leading when it comes to forward thinking on subjects such as sustainability and inclusion. In a world where food security and the sustainability of the food and agricultural system are two of the world's biggest issues, we believe that the food movement has an important role in changing food culture. Low Food will therefore act as a networking agent and platform where new ideas are created and implemented."

See **lowfood.nl** for more information.

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