FOOD FOR THOUGHT

Your DIY guide for creating bioplastics

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PREFACE

Food for Thought is a research program that uses food as a starting point for thinking about real-world material practices. We live in challenging times. So many of humanity's everyday practices are damaging the environments that we rely on to thrive, and the impact is being felt by all of the living entities with whom we share this planet. These practices—the things we do—are culturally situated. They are learned, ingrained; sometimes they are unconscious. In any case, they can be hard to change. Food for Thought grapples with this problematic using the familiar material of food. Food is social. It is political. Everybody eats, in some form or another. A person may claim that they don't do science (though it's hard to imagine how this might be true), but no-one can claim that they don't eat, yet still flourish.

The experiments unfolded in this book were undertaken by six Masters students in the ITPD MSc program at the University of Southern Denmark in Kolding, over the Spring semester, 2018. The project was their research apprenticeship—a semester-long engagement with a professor, learning research by enacting it in a real-world research project.

Over the course of four months, Iulia, Jaleh, Katya, Ona, Paul and Valeria used participatory research-through-design to engage with open source biology, and bring varied stakeholders together to grapple with the question: How can we shift our material practices around food towards ecological flourishing? In particular, they looked to plastic, which is a key environmental issue. Plastic is commonly used to cook, distribute, eat, store and dispose of food. It was first proclaimed an amazing innovation. Now we find it permeates everything—not only the tools we cook and eat with but the food itself, the soil and water that our food grows in, many living creatures on our planet, including ourselves.To complete their apprenticeship, the six students made this book. It is at once a design artefact, a report, an invitation and a call to arms. We hope you enjoy it.

DANIELLE
WILDE

Associate Professor, Embodied Design
Director**,** BodyBioSoft Lab
Institute for Design and
Communication University of Southern
Denmark, Kolding

Management Committee Member for
Denmark European Network for
Environmental Citizenship (EU COST
Action CA 16229)
http://www.enec-cost.eu
www.daniellewilde.com
www.sdu.dk

GELATIN-BASED PLASTIC BOWL

Food by: Design School Kolding

IULIA ELENA GAVRILIUC

The reason why I chose Food for Thought as my professional apprenticeship is my fascination for the contemporary culinary scene and my interest in how our eating habits and the materials used for food packaging or cutlery become more and more controversial in today's world.

Exploring how humans will produce and consume food in the future is a thought-provoking process and a conversation starter for greater problems caused using plastic.
As a graphic designer, I was interested how the message we are trying to spread can be conveyed into an accessible source for anyone to benefit from.

JALEH BEHRAVAN

Climate change and destruction of nature are our first issue of today's world. Consider this fact, the way we are behaving our nature all over the world should be the designer's priority. "Food for thought" project is an opportunity for me to reach this goal to find an alternative way of consumption and making eco-friendly cutleries. In other hands, exploring materials and learning new techniques makes me motivated to be a part of this journey.

Furthermore, I am thinking of this project as a continuation of design specialization project where I am experiencing to work with new biomaterials and engage with participatory forms of research through the design process.

JEKATERINA ALEKSEJEVA

Everybody eats – this is an undisputable truth, a vitality of our existence. The goals of this project strongly resonate with my personal values – to reduce the amount of pollution and environmental impact caused by human behaviour.

The use of plastic in industries is becoming overwhelming and by participating in this project I seek to contribute by exploring alternative ways that bioplastics can offer.

ONA ORLOVAITE

Within the last couple of years, environmental awareness has become an increasingly more significant concern in my daily life. Awareness of consumerism as a part of our culture and the damages it brings has been brought to my attention by following various campaigns and documentaries. Our eating habits seem to be hurting not only ourselves but also our planet.

By becoming a part of the team, I can bring numerous examples of how environmentalism as a mindset can be implemented in our daily lives without much sacrifice and advocate for the great need of conscious consumption using my knowledge about environmental issues.

PAUL BIEDERMANN

The continuously increasing pollution of our environment and particular the damage of micro plastics in our food and everywhere else, caused by plastic straws, cutlery and other disposable objects is a large scale issue. The idea of regrowable, hyper-compostable or even edible cutlery seems to be a very meaningful project to me.

My main interest is drawn in exploring material properties and how we can tune them to create functional and aesthetical cutlery, that doesn't lack any of the characteristics of common table ware or even brings up new features and ways of thinking. Moreover I am interested in the production methods like casting or 3D-printing and producing exceptional designs, that challenge our perception on the way tableware has to look like.

VALERIA VISMARA

I chose this project since I feel the theme is very relevant, and only will be more so in the future. Land degradation and increased deforestation due to unsustainable farming and husbandry practices, resulting in poor condition for both the eco-diversity and livestock are themes very close to my heart.

Hence why I decided to embark on this journey, to gain more knowledge and better myself as a person by adopting a new attitude towards sustainability. I firmly believe we can make a difference by adopting few powerful actions to try reducing wastefulness as much as possible, but most of all by learning: what's the current practice, what has been done around the world and what can I do.

ROOT VEGETABLE CHIPS ON A COFFEE BASED BIOPLASTIC PLATE

Food by: Design School Kolding

1 INTRODUCTION

1.1 PURPOSE

The objective of this book is to make people aware that there are already better alternatives to plastic available both online and in local stores. The problem is that they're not always easily obtainable and can be quite expensive as well. Our purpose, following the principles of Liboiron's feminist laboratory of equity, place-based knowledge and ethical politics (Liboiron, 2017, read more on https://civiclaboratory.nl), is to try democratizing the process of creating bioplastic by offering our readers the opportunity to create their own dishes and cutlery with local, easily obtainable ingredients that are accessible at a fair price.

In this book, we will cover our complete journey from discovering the recipes, to finding some alternative options and playing with materials. Attached, you will find the recipe book, which is free to use, distribute, and, of course, experiment with.

So, what exactly is plastic and what are plastics derived from?

From a chemical point of view, plastics are polymers. This is why many plastic types begin with the word "poly," for example, polyethylene, polystyrene, and polypropylene. Plastics were historically crafted as a solution to the scarcity of rare materials such as tortoise shells, horn and ivory (Science History Institute, 2016).

While the ground ingredients of plastic production are basic, its production is a tightly kept secret, and plastic production facilities are comparable to tightly guarded fortresses (Connacher, 2008). The issue is that people who are not involved in making the plastics rarely know which chemical additives are used to create different plastic recipes, and a lot of plastic products are often used as food packaging.

The use of plastic has become so dominant in our daily lives that on average, a single Dane generates around 160 kg of plastic per year (EUROSTAT, 2018), the majority of which goes to landfill.

Unfortunately, plastic does not rot or compost. It can last up to five hundred years in our oceans and approximately a thousand years in our landfills.

Until the 1990's it was entirely legal to dump plastic into the sea, and most of it is still floats around in our oceans or lands on our shores. A study published in 2017 estimated the amount of plastic dumped yearly into the ocean to approximately eight million tons (Plastic Oceans Foundation, n.d.). Thanks to oceanic currents, before 2025, a new continent will be born, one the size of Europe, one entirely made of plastic.

Why should I bother?

Due to exposure to elemental forces, over a long time, plastic breaks down into microscopic parts that are less than 5 mm in diameter. These tiny parts are commonly referred to as microplastics. These particles attract and absorb high quantities of dangerous chemicals such as agricultural and industrial toxins. Our oceans are so polluted that in some areas there is up to six times more plastic than plankton (Le Guern, 2018).


SDU


SDU
SDU

Many animals mistake these microplastics for food and ingest a huge quantity of them while, practically, starving to death.

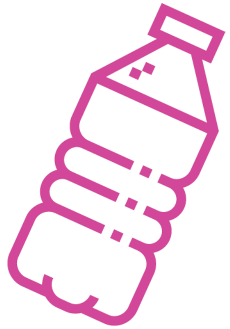
Statistically every year more than a hundred thousand marine animals, birds, and sea turtles die of starvation or because their stomach ruptures from the ingestion of plastic (ibid). On the other hand, some of the animals that survive despite eating plastic, end up on our plates. Problems arise when plastics are digested because the toxins that are bound to the microplastics are released into our body. The reason being that stomach fluids are a stronger binder than microplastics. All the dangerous chemicals go directly into our bloodstream.

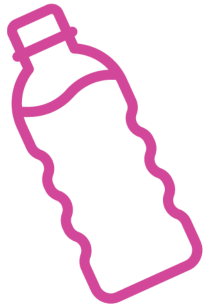
The price for ingesting plastic is a steep one–"findings suggest [microplastics] can translocate across living cells to the lymphatic and/or circulatory system, potentially accumulating in secondary organs, or impacting the immune system and health of cells" (Kelly and Wright, 2017) (European Commission, 2011, p.1).

Why should I bother?

Making bioplastic or edible cutlery is not new–the number of alternatives available to buy in the stores is rapidly growing. During this project which lasted for only four months, we observed the change in the political discourse on plastic–resulting in a proposal on banning plastic straws in UK reaching the parliament (Bruner, 2018). As mentioned above, there are already commercially distributed alternatives to, e.g., plastics straws—LOLIWARE, for example, produces plastic straws and cups from seaweed, Pasta Straw™ is rather self-explanatory, and The Final Straw's retractable metal straw is suggested to be taken with you wherever you go.

The problem, as mentioned above, is that many of these products are hard to find, they're not available in many countries, and have a higher price point than their plastic alternatives. This is why, we focused on developing a recipe book based on ingredients which you could find in a grocery store or a pharmacy. We want to make the process of making bioplastic and edible cutlery more democratic, less costly and, most importantly, accessible to a broader audience.





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GREEN SALAD WITH HERBS SERVED IN A PIE CRUST DISH WITH PIZZA DOUGH CUTLERY

Food by: Design School Kolding

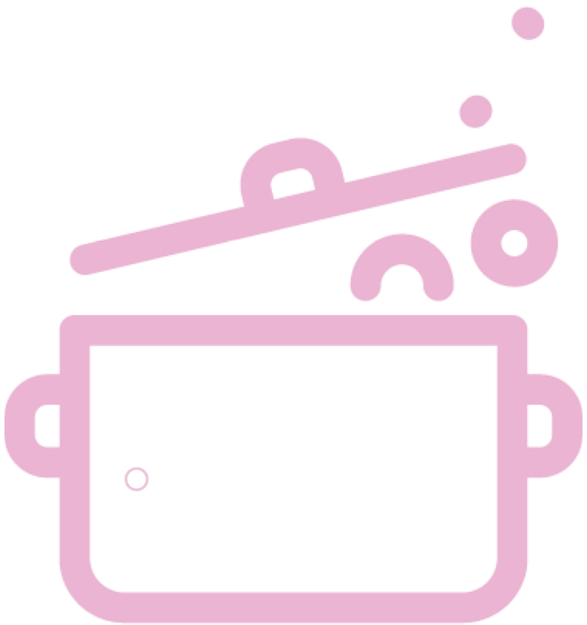
2 CONTRIBUTION

What online material was available prior to approaching the topic of bio-plastic and edible cutlery?

At the start of this apprenticeship, we were given several instructions sets from the online environment. These sets were not difficult to find online, however, the way the recipes were presented was at times unclear and often with a minimal amount of information about how the material should behave during the process. We could not identify a reason why people should adopt this new way of thinking merely by looking at them. The recipes were correct, but not presented in an approachable form.

We wanted people to feel like making bioplastic was an accessible task, that everyone could do in the comfort of their own home. Sometimes, when looking for recipes online people might feel lost, or that the instruction sets are very unclear. Is the recipe as simple as they claim, and do they skip some step, because they think they're obvious?

We are not scientists, biohackers or molecular gastronomists. We all have, in some ways, a relationship with food and cooking, but we started this project just like the readers of our book, as explorers. Our aim is to contribute to this field and shift people's understanding of the impact they can have on the environment; therefore, we reshaped the instruction sets in a form which we believe is meaningful and convenient for anyone.



2.1 DIY RECIPES

GELATIN BIOPLASTIC (HARD PLASTIC)

INGREDIENTS:

* 120 ml cold water
* 24 g gelatine
* 6 g glycerol

INSTRUCTIONS:

1. Put the water in a clean pot and add the gelatin followed by glycerol;

2. Stir the mixture until no clumps remain;

3. Heat the mixture up to 95° or until it starts to froth, while continuously mixing;

Tips: Check the temperature with a food thermometer To achieve a clear sheet of gelatin remove all the excess froth with a spoon;

4. Pour the mixture in the desired mold;

5. Leave to dry for a couple of days making sure the gelatin doesn't stick to the mold.

Optional: Try adding spice/condiments to the mixture or food colouring.

MATERIAL PROPERTIES:

Water resistance: gelatine-based bioplastics will gradually start to melt if left in hot water (60°C) and cast a layer of slime across the surface. The slime will disappear once the bioplastic is taken out of the water to dry.

Temperature resistance: when gelatine bioplastic is put in the microwave on high, even for as little as 30 sec, will start to bubble and break apart. In contrast, we had no issues using gelatine-based bioplastic at room temperature.

Material evaporation: The water component of the bioplastic solution will evaporate through casting period and shrink the cast object. The thickness of the material shrinks up accordingly.

Plasticity: this property is informed by the relation between gelatine and glycerol. While gelatine acts as a hardener, glycerol has the function of softener. More glycerol results in higher plasticity.

Colour and smell: gelatine-based bioplastic has a yellowish colour. It is transparent, but if the foam is not removed during the cooking process it will have a solid white colour.

Gelatine-based cutlery

When cooked it has a strong smell of burning animal skin. It is therefore to cook it with extraction or in a well-aerated room. As discussed before, additives, such as coffee or citrus peel, can be added during the cooking process to mask the smell.

MARSHMALLOW GELATIN BIOPLASTIC (SOFT PLASTIC)

INGREDIENTS:

* 120ml cold water
* 144g gelatin
* 72g glycerol

INSTRUCTIONS:

1. Put the water in a clean pot and add the gelatin followed by glycerol;
2. Stir the mixture until no clumps remain;
3. Heat the mixture up to 95° or until it starts to froth, while continuously mixing;

Tips: Check the temperature with a food thermometer

4. Pour the mixture in the desired mold;
5. Leave to dry for a couple of days making sure the gelatin doesn't stick to the mold.

Optional: Try adding spice/condiments to the mixture or food colouring.

MATERIAL PROPERTIES:

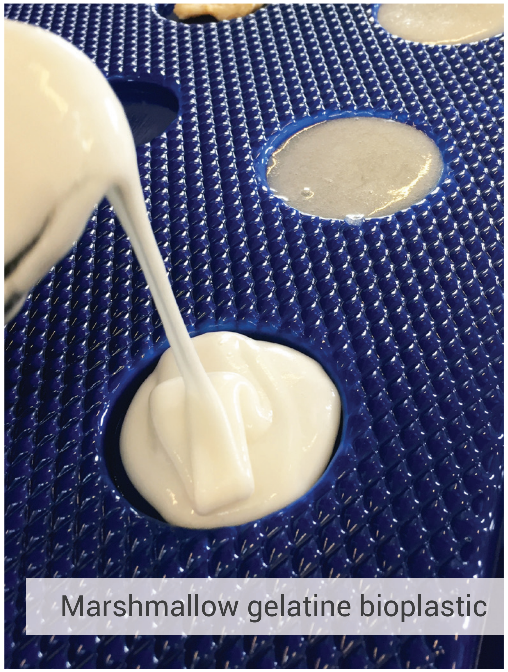
Water resistance: marshmallow gelatine bioplastics are drastically melting if left in hot water (60°C), even after a short time. After cooling down, the material remains very elastic.

Temperature resistance: when gelatine bioplastic is put in the microwave on high, even for as little as 30 sec, will start to bubble and break apart. In contrast, we had no issues using gelatine-based bioplastic at room temperature.

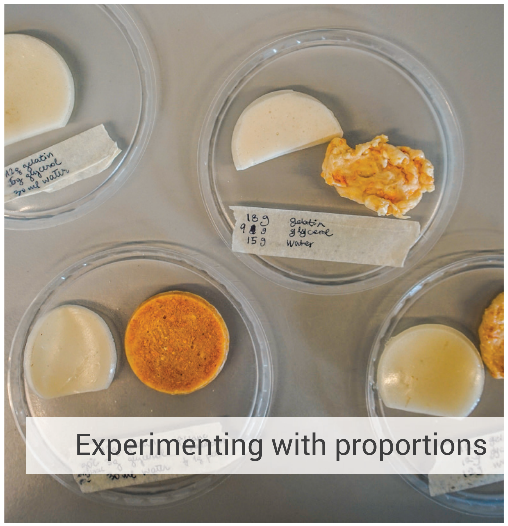
Material evaporation: The water component of the bioplastic solution will evaporate through casting period and shrink the cast object. The thickness of the material shrinks up accordingly.

Plasticity: this property is informed by the relation between gelatine and glycerol. While gelatine acts as a hardener, glycerol has the function of softener. More glycerol results in higher plasticity.

Colour and smell: gelatine-based bioplastic has a yellowish colour. It is transparent, but if the foam is not removed during the cooking process it will have a solid white colour. When cooked it has a strong smell of burning animal skin. It is therefore to cook it with extraction or in a well-eraded room. As discussed before, additives, such as coffee or citrus peel, can be added during the cooking process to mask the smell.



Marshmallow gelatine bioplastic



Experimenting with proportions

STARCH BIOPLASTIC (RUBBER-LIKE PLASTIC)

INGREDIENTS:

* 11 ml cold water + 1,5g of baking powder

* 37,5 ml of cold water

* 4 g starch

* 7,5 g of vinegar

* 11 g glycerol

INSTRUCTIONS:

1. In a container mix the baking powder and water (11 ml water + 1,5 g baking powder) and set aside;

2. In a cooking pot mix the rest of ingredients;

3. Heat and stir until it thickens;

4. In the pot pour the first mixture of baking powder and water and stir until it boils, and it reaches a gooey consistency;

5. Spread the outcome in a mold or mold it in the desired shape;

6. Allow to dry for 1-2 days.

Optional: Try adding spice/condiments to the mixture.

MATERIAL PROPERTIES:

Water resistance: starch-based bioplastics will drastically start to melt if left in hot water (60°C). Even after a short time (ca. 30s), the material becomes very gooey and remain porous after casting again.

Temperature resistance: when starch bioplastic is put in the microwave on high, even for as little as 30 sec, will start to burn and seperates into

its ingredients.

Material evaporation: starch-based bioplastic has a solid consistency and shows only minor signs of material evaporation when casting.

Plasticity: this property is informed by the relation between starch and glycerol. While starch acts as a hardener, glycerol has the function of a softener. More glycerol results in higher plasticity. The recipe shown above should result in a rubber like material

Colour and smell: starch-based bioplastic has a transparent milky colour. When cooked it is fairly neutral in smell with a slight note of corn or potato (depending on the starch).

Starch-based bioplastic

AGAR/STARCH BLEND WITH SORBITOL (PLASTIC FOIL)

INGREDIENTS:

* 1.5 g sorbitol
* 3.0 g starch
* 300 ml water
* 0.75 g agar-agar
* 120 ml of 1% glycerol solution

INSTRUCTIONS:

1. In a cooking pot mix all the dry ingredients (starch, agar and sorbitol);

2. Add the water and glycerol to the mixture slowly while stirring constantly;

3. Heat the mixture up to 95° or until it starts thickening;

4. Spread the outcome in a mold or form it in the desired shape;

5. Allow to dry for 1-2 days.

Optional: Try adding spice/condiments to the mixture or food colouring.

MATERIAL PROPERTIES:

Water resistance: The thin material melts instantly in 60°C hot water.

Temperature resistance: When heated in the microwave, the agar/starch blend dissolves immediately.

Material evaporation: sorbitol bioplastics evaporates to almost 90 % of its volume of initial volume.

Plasticity: casts a thin layer that is flexible and fairly robust. It could be used as a alternative to food foil.

Colour and smell: transparent colour, no distinguishable odour.

Sorbitol solution foil

Curing process

EDIBLE CUTLERY (PIZZA DOUGH OR PIE CRUST)

INGREDIENTS:

* Pizza dough or pie crust
* Water (for the pie crust)
* A pinch of your imagination

INSTRUCTIONS:

1. Preheat the oven to 200° C. Line baking paper on the oven's grill;

2. Make the pie crust as shown on the box. Or simply open the pizza crust package;

3. Re-imagine cutlery and create shapes;

4. Bake the cutlery for 15-20 minutes. Lower the temperature to 150° C if needed.

Optional: Try adding spice/condiments to the mixture.

PIZZA DOUGH:

We used freshly pre-made pizza dough, both whole grain and more highly processed(white).

Temperature: Bake the dough for 15-20 minutes in a 200 °C preheat oven. Give it extra time and lower the heat to 150 °C if needed.

Shape: The pizza dough after cooking time becomes puffy because of active yeast. The result, in conventional shapes was not satisfying. The bowl part of the spoon was too puffy. Although it looks like a spoon, it does not function well. We altered the design from a traditional form to more minimal form using triangular and round shapes with a low edge in one or both two sides to hold more food on it.

Colour and smell: the smell of the finished cutlery is similar to home backed bread. The colour of the cooked pizza dough is getting golden brown.

PIE CRUST:

Pie dough is a simple combination of flour, fat, salt and a little water. we used a commercial pie crust kit to save time and make it easy for everyone to try at home. The pie crust that we tried was mealy or short flake pastry.

Temperature: Bake for 35-40 minutes in a 200 °C preheated oven. lower the heat to 150 °C and give extra time if needed.

Consistency: This dough produces a crisp, but not flaky crust. It does not puff and has a good strength.

Shape: We cooked the dough between two spoons to keep it in shape. For larger dishes like a bowl or tray we tried blind-baking. To blind-bake a crust, line the chilled dough with parchment, then fill it with weights (dried beans).

The crust is evenly browned and golden brown around the edge, somewhat lighter brown on bottom. It holds its shape when cooked. The problem with producing traditional cutlery this way, is that the part which connects the bowl to the handle is too fragile.

Pie crust cutlery

EDIBLE CUTLERY
(RICE, MILLET AND WHEAT)

INGREDIENTS:

* 80 ml of water
* 60 g millet
* 20 g rice (or rice flour)
* 20 g wheat

INSTRUCTIONS:

1. Preheat the oven to 200° C. Line baking paper on the oven's grill;

2. In a bowl blend the dry ingredients;

3. Slowly add the water and

form a dough;

Tip: In case the dough is too dry, add water in small quantities until it reaches the desired consistency;

4. Form the dough in the desired shape, or use a cookie cutter;

Tip: Use some flour to avoid the dough sticking to the cookie cutter or your working surface;

Optional: Try adding spice/condiments to the mixture.

5. Bake the cutlery for 15-20 minutes. Lower the temperature to 150° C if needed.

This recipe was developed by an Indian company who sells mass-produced edible cutlery. The recipe has four simple ingredients: millet, wheat, rice, and water. Making the recipe match their result is tricky without an industrial press. (https://www.youtube.com/watch?v=TjUzGR2aOLw)

Temperature: Depending on the oven, the cutlery can be baked for 15-20 minutes at a temperature between 170 and 200 degrees Celsius.

Consistency: experimenting with whether to cook the rice beforehand or add more water to the mix gave

alternatives to the lack of industrial press situation.

The best result, in terms of consistency, turned out to be when the rice is cooked and crushed into a paste that goes with the rest of the ingredients. In that case, less water is needed, and the dough becomes smoother and easier to handle.

Shape: The dough should be thick but flexible enough to mould into shapes or cut with a cookie cutter. Placing the dough on a pre-oiled metal spoon, for example, will keep the exact shape of it in the oven.

Taste: it has a neutral flavour. However, adding a pinch of salt gives it a more palatable taste, like a fitness snack.

Rice, wheat & millet

Baked rice, wheat & millet blend

2.2 CURING PRACTICES

Curing is one of the most important stages in creating bioplastic cutlery and tableware. Besides the relation of ingredients used, access to oxygen also impacts the process.

The best curing results were obtained when the area of surface exposed to oxygen was the largest. For example, when we poured a gelatine-based bioplastic into a wooden frame and leaned the frame against the wall, we could expose both sides of the curing bioplastic layer to oxygen. Good outcome was also achieved in gelatine-based cutlery that was left to cure on a silicone matt with only one side of the cutlery exposed (for reference see page 35).

The second-best result in terms of curing was achieved when we laid bioplastic canvas over bowls to cure. The weight of the bioplastic sheet pressed the material to the surface of the bowl and oxygen did not reach the inner side. Attention was needed to determine when the tableware was hard enough to sustain the shape and be removed from the bowl to complete the curing process. In this method we understood that the thickness of material can lengthen or shorten the curing time.

Curing bioplastic that is encapsulated in the complex-shaped mould is most challenging. When there is less air on the surface the material does not harden completely. Rather it turns into a more flexible soft form. This was seen when using a 3D printed mould to cure gelatine-based bioplastic between two spoons (for reference see page 35).

2.3 REFERENCES

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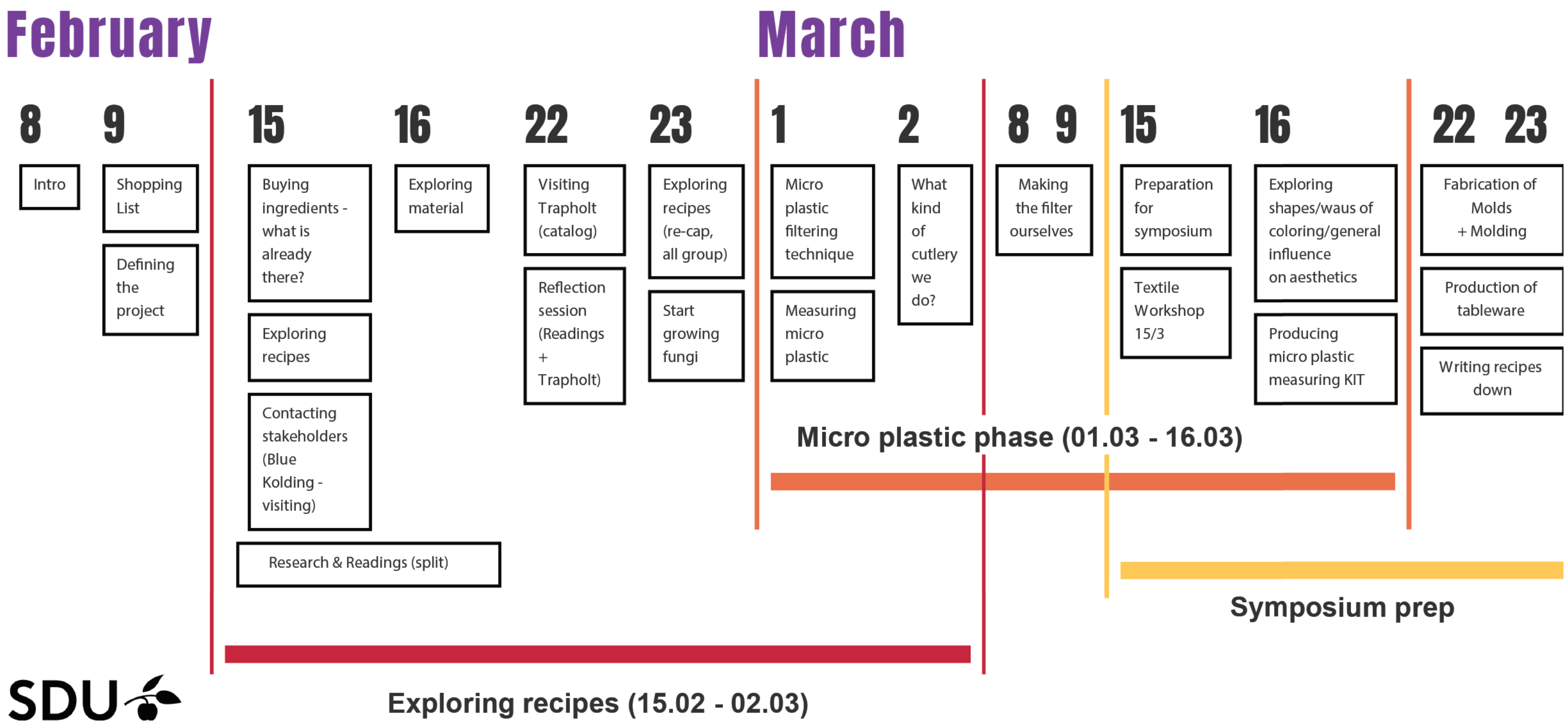
APPLE MERINGUE WITH PARSLEY ICE-CREAM, SERVED WITH SYRUP-FRIED PARSNIP AND PICKLED ONIONS IN BLACKBERRY JUICE IN A VANILLA BIOPLASTIC BOWL

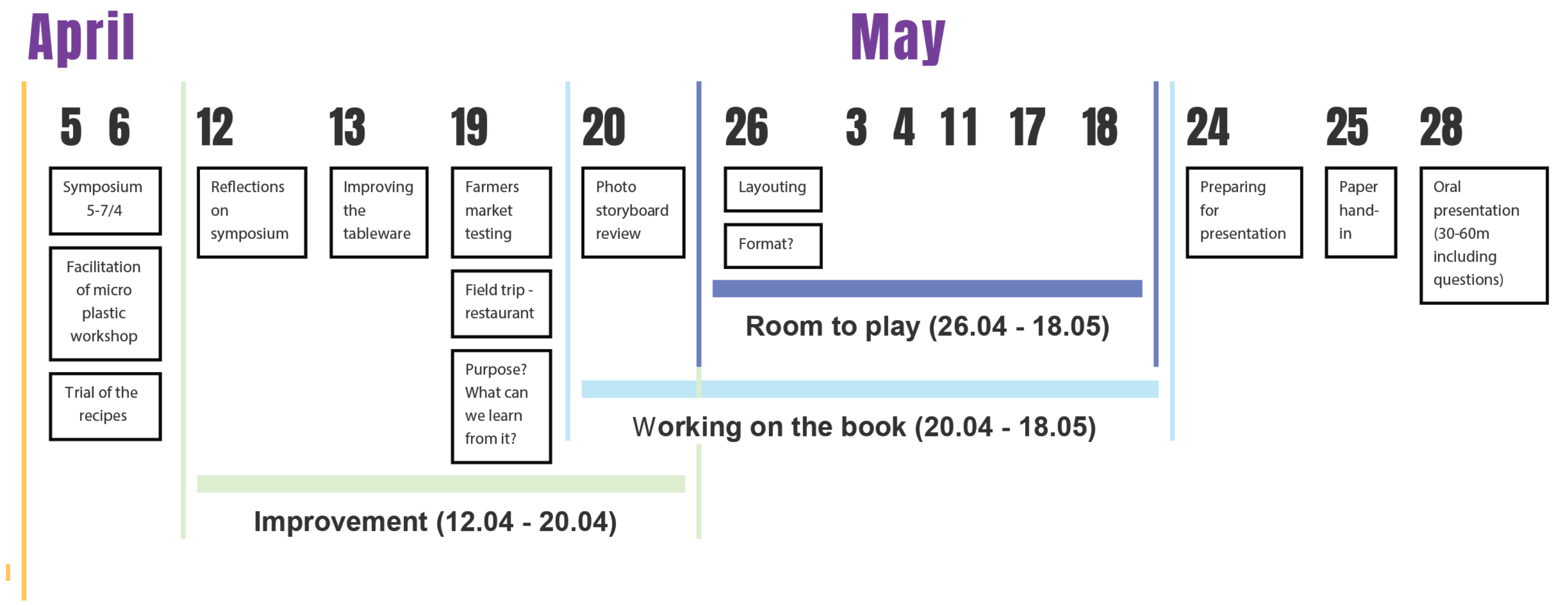
Food by: Design School Kolding

3

METHODOLOGY

In this section, we discuss our methodology in detail—the organization of time, steps of the process, shift in our focus throughout the process, as well as the reasons for that.





Project plan, 2018, February 9

3.1 SOFT START

The initial setup of the project was to divide the pre-defined subtopics among three smaller teams among the apprentices. Each person came in with their motivation for the project and varying interests, which were put on the table and made known to the group. We decided to divide the topics among three subgroups, which could focus on the following issues: bioplastics, edible cutlery, and microplastics. One of the first challenges faced by the team was to find common ground between the three themes.

What is the common denominator between edible cutlery, plastic that we can eat and microplastics that we consume unintentionally? We wanted to deliver suggestions to what alternatives could be used in place of conventional products. The answer to that has been obscure, but in plain view—water was the "ingredient" present in all projects. We decided to aim at producing a filter in home conditions, then clean the raw, unfiltered water from the local river or fjord and use it in the production of edible cutlery—grain-based as well as bioplastic.

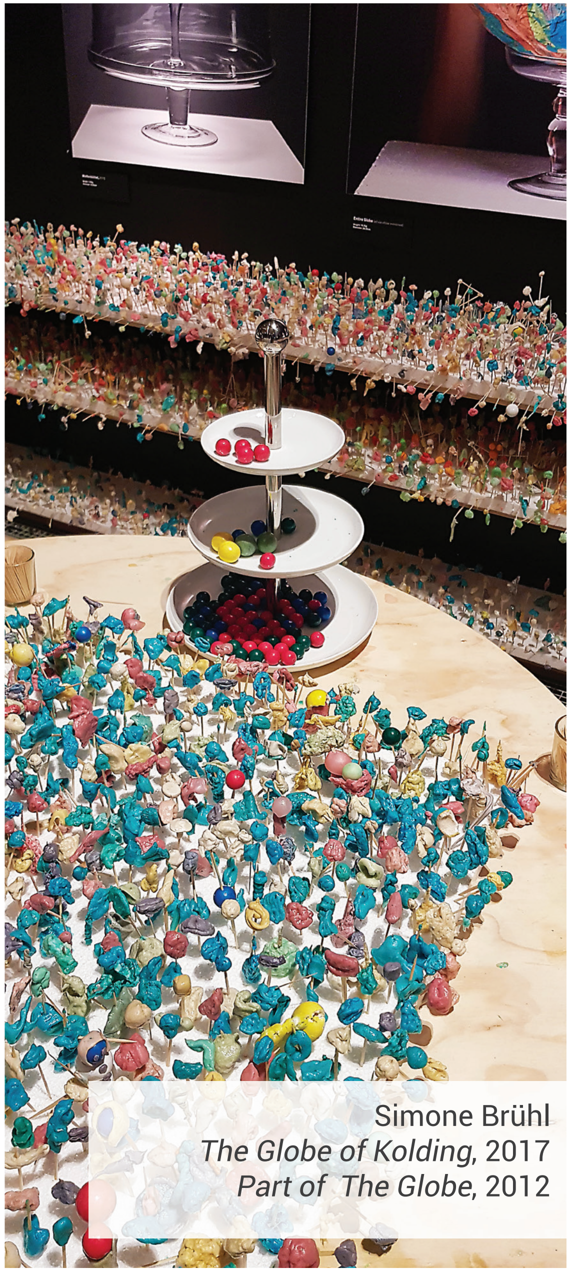
The projects took off instantly—the microplastics team contacted the local water plant to learn about cleaning wastewater on a big-scale and cooked the first batches of recipes available online. By the end of the first week, we had gained a general idea of how demanding it is to work with different materials and a rough image of the variety and diversity of the qualities that bioplastics possess.

3.2 EAT ME

To gain more knowledge about alternative ways of thinking and eating, the team visited the exhibition "Eat Me" at Trapholt, art museum in Kolding.

"Eat Me is an exhibition about how we understand ourselves and the world through food. Food is the supreme metaphor of our time. We use food to comment on practically anything: our social problems, our cultural habits, our identities, our understanding of nature. We use food to set boundaries, refine our sensibilities and project our visions of the future" (Trapholt, n.d.).

The thought-provoking collection made us rethink the way we eat, consume or in other ways use food. The exhibition



Simone Brühl
The Globe of Kolding, 2017
Part of The Globe, 2012

aligned with our wish to work with sustainable design as there was a lot of focus put on the industrial production of meat, which is known to be the big sinner when it comes to water footprint. “Only 4% of the water footprint of humanity relates to water use at home. This means that if people consider reducing their water footprint, they should look critically at their diet rather than at their water use in the kitchen, bathroom, and garden" (Hoekstra, 2012).

Our ways of living are increasingly becoming a significant burden on the planet which we can no longer ignore—we needed to reflect upon what we eat and the way we do it. We a came back to the soft-lab with an altered understanding of our project objectives, especially on the aesthetic level. It framed our visual thinking and encouraged us to consider designing the tableware in a more artistically inclined manner, as well as to present it in such way.

3.3 WORK WITH MICROPLASTICS

Our process working with microplastics was not as linear as originally intended. Although we managed to get a meeting with Blue Kolding on short notice, and visited the wastewater plant soon after that, the focus on microplastics faded away long before the end of the project due to the challenges we faced. For instance, Blue Kolding, the company which runs 15 billion liters of water through their cleaning system yearly is not financially capable of ensuring the removal of microplastics from the water. The filtration of the particles seems to be incompatible with the amount needed to be processed. Not only that—as Karin Refsgaard, the executive director, expressed it, the issue seemed to be far from being the top priority for the company.

At that point, the microplastics team needed to rethink their strategy. If tiny pieces of plastic are not a big concern on the municipal level, is it something that individuals can be bothered with? Further research shows that 9 out of 10 water bottles contain microplastic (McCarthy, Richter, 2018). The prevalence of microplastics in Danish tap water (Wenande, 2017) brought the topic into the spotlight, since the local water resources are considered to be of the cleanest in the world.

Our further inspection of official reports addressed the issue of how waste material from the cleaning process—the sludge—is used as a fertilizer in fields and is highly contaminated with microplastics. “The soils that had received sludge had twice the microplastic content than the soils that had not" (Vollertsen, Hansen, 2017. P. 30). The problem with not investing in the removal of the plastics from the wastewater is that we are allowing the microplastics to enter the soil, and subsequently the food chain (ibid).

The gravity of the issue motivated us to look further for ways to detect and measure microplastics in local water. We analysed the sources available online (Masura et al., 2015; Liboiron, 2015), contacted researchers in Denmark with a request to visit their labs. Our goal was to understand the techniques used to detect microplastics in a lab environment and interpret them in a democratic manner (Liboiron, 2017).

Lab equipment at Blue Kolding

Following the CLEAR lab, we created sieves for filtration of water in the river near the university. We tried out different materials, varying in density. Muslin seems to have the most potential of the three that we produced–single-layer rayon tulle, double-layer rayon tulle, and muslin. The latter one was dense enough to create pressure on the inside of the sieve and worked as a fine filter for the particles passing through.

Unfortunately, most lab methods require equipment which was neither accessible to the people willing to do that at home nor to us. This limitation put the project beyond the scope of our abilities. The particles that we collected in the sieve were not as easily recognizable as plastic, and our lack of experience in testing it in a lab setup turned out to be a hard issue to overcome. The microplastics project was eventually taken over by Tau Ulv Lenskjold, a Post-Doctoral researcher at SDU who then ran the microplastics workshop during the FOOD+ symposium (more on that on p. 40). The focus of the team shifted towards bioplastics and then edible cutlery.

3.4 BIOPLASTICS – MAKING AND EXPERIMENTING

This subchapter introduces the bioplastic recipes which were used as our starting point and discusses the findings, as well as challenges which the recipes pose.

a. Protein-based plastics:

* Casein based bioplastic from milk

* Casein based bioplastic from cream and lemon juice

* Gelatine based recipes (Hard & Soft)

b. Starch-based plastics

c. Agar-based plastics:

* Pure Agar

* Agar Starch Blend

* Gelatine-Agar Blend

d. Sorbitol-based plastics

There are plenty of online instruction sets on how to use gelatine, agar, sorbitol or milk to make bioplastics. To begin our professor gave us a set of recipes, some of which had been tried before. The advantage of the tools used in the recipes is that most are accessible and can be easily found in the kitchen, in the local supermarket or online. We worked at SDU BodyBioSoft lab in Kolding. At the beginning, we tried all of the recipes listed. The result was not satisfying–most of the samples shrank and deformed, which was not indicated in the instruction sets. We found out the amount of water we added to the gelatine-base recipes can change the result completely.

The frustration prompted us to reconsider the ways that the instructions are made. Likewise, the outcomes of the casein-based recipe were out of expectation since it dried out completely and we couldn't remove it from the surface; it ended up with too many cracks and deformations. Further, the outcome was paper-thin and fragile.

These outcomes were surprising for us–none were indicated as possibilities in our online research. This finding suggests that the recipes were missing information. We continued to work with the recipes that gave us in a better result, comparing outcomes during the making process. Bio plastics recipes thus became our main focus in this project, since we could improve the process over time.

In the gelatine-based recipes we tried to apply the material on a flat surface to see how it cures and how can we shape it. Afterwards, we tried to apply it on bowls and cast it in different ways,

PIE CRUST BOWL AND FORK

Food by: Design School Kolding

such as placing partially cured sheets in between spoons, forks, etc. (more on the p. 38).

We learned that the thickness of material has a huge impact on the outcome. In general, for making bio plastic instructions, we tracked the following methods: (see chapter 4 for more detailed descriptions).

1) Mold making and Preparation

2) Mixing

3) Heating

4) Molding

5) Drying /curing

3.5 EDIBLE CUTLERY

One of the first edible cutlery recipes that we tried was made of millet and rice. The clay-like texture of the dough allowed us to explore a wide range of forms and shapes, which seemed to have a lot of potential. This first experience of producing it and tasting the product inspired us to turn to even more widely available options which could be purchased in the store: pizza dough, pie crust, chocolate. Later in the process, we 3D-printed cookie cutter forms for the production of spoons and forks. They, unfortunately, did not change the bland taste of the rice-millet product. We wanted to explore more with the flavours of the edible cutlery which could enhance the gastronomic experience – see chapter 2.1.

Although the possibilities with the edible cutlery were endless, this part of the project did not receive as much attention, especially while approaching the end of the project. One of the reasons for that shift was that exploring the process of making bioplastics offered us countless opportunities to learn, and, frankly said, was more exciting to dig deeper into. The other reason for abandoning the edible recipes was that they need to be under pressure to become firm and rigid for using and we could not access the hydraulic press.

Experimenting with chocolate

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RAMSONS PIE ON AN ESTRAGON GELATINE BOWL

Food by: Design School Kolding

4

ENGAGING WITH EXISTING PRACTISES

We started to explore resources that potentially could be used to develop an approach for cutlery and tableware production. In the SDU Maker Lab, fundamental options included a laser cutter, vacuum press and 3D printer.
Our goal was to generate an approach that is rapid, and in its own way is directed towards minimizing an ecological footprint.

LASER CUTTING

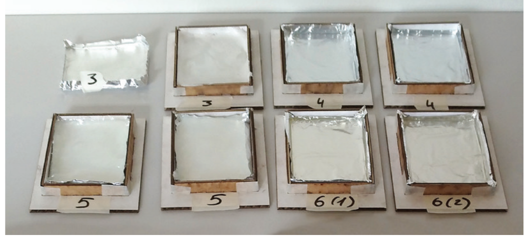
A first use-case of laser cutter came in practise when we cooked the first attempt at gelatine-based bioplastics. To compare different attempts at gelatine-based bioplastics, we needed uniform moulds. We worked with a cardboard mould, 4cm sq, with 2cm high sides, lined with aluminium. It was an efficient approach, with our discovery that aluminium foil needs to be lubricated with olive oil before pouring in bioplastic solution.

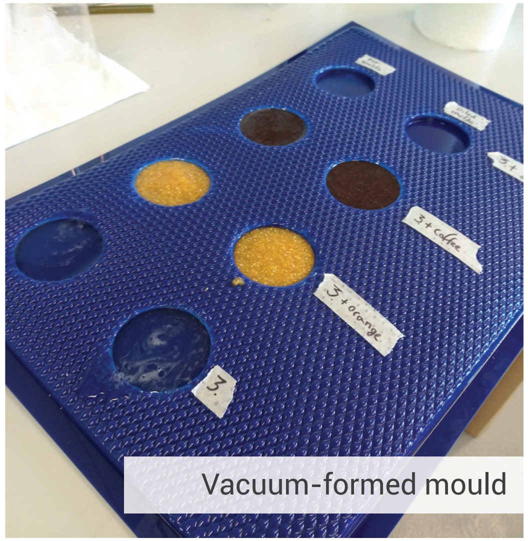
VACUUM FORMING

After our first experiments, it became clear that we needed more robust forms to cast multiple bioplastic tests. Having separate chambers for every bioplastic type was sufficient for small quantities, but bigger scale experiments would require a larger number of chambers and that would overcom plicate a process of casting. For these reasons we decided to use 8mm medium density fibreboard (MDF) and vacuum press casting mould in it. We chose circles for the casting shape, cutting them out of 6mm thick wooden board. The thickness meant that we could observe material evaporation. After pressing MDF forms it was hard to get the wooden circles out of plastic sheets, but they could be reused for several sheets, so the effort was worthwhile. The overall result was satisfying, and the method became our preferred way of producing casting moulds during the project.

We also considered producing silicone moulds or more sustainable moulds, but we understand that some these plastic alternatives might be completely unsustainable. Future research will look into how we could better support these kinds of activities in a more sustainable ways.

Laser-cut moulds





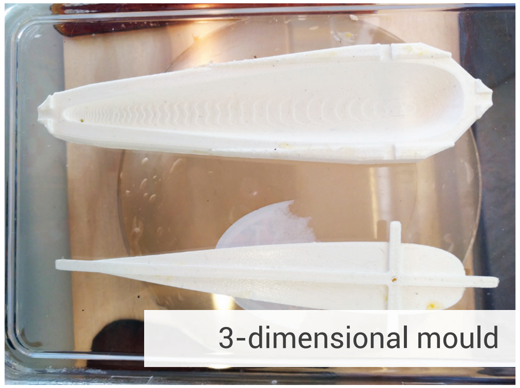
Vacuum-formed mould

3D PRINTING

3D printing is an advanced technology used in the variety of fields (medicine, housing, hobby. With the right equipment a person can print any irregular shapes and curves. Within this project we used it for several purposes. First, we created a negative model of the object we wanted to cast using bioplastics. We constructed a 3D model of a Chinese spoon, or duck spoon and cast it with gelatine-based bioplastic.

As discussed, we worked with a number of materials to explore edible and hyper-compostable cutlery. While working with pizza dough we noticed that it can be treated as a canvas to cut out forms as for cookies. It was challenging and inaccurate to do this by hand so we 3D-printed 2cm tall outlines of a spoon and a fork to try the approach. Printed tools were comfortable both to use and to cut the dough.

Other practises that we engaged with related to the material's solidity form. Since bioplastic at a different time of casting can take different solidity form, we had a variety of options when to interrupt the formation of material and shape it to our interest. We worked with a liquid form of bioplastic as well as solid one and also interacted with soft forms.



3-dimensional mould

Cookie-cutter

HARD

Through our experiments, we discovered that gelatine-based bioplastics quickly become solid hence we used this property to produce square sheets of material that later can be hand-crafted. Our approach consisted of preparing a bioplastic solution, casting it in the tray of 30x15cm size and experimenting with this canvas. Our first method was to lay down cutlery on the sheet of bioplastic and with a knife cut out the shape.

We aimed to repeat spoons, forks and knives but quickly noticed that narrow parts were challenging to cut. Material often broke, requiring careful and mindful interaction.

Another complication was to recreate a 3-dimensional form with a 2-dimensional canvas. We produced several variations of casting options. Our idea was to let the material dry in the desired form. Consequently, we had bioplastic articles drying directly on silicone canvas, others were drying on top of the object they've been cut around. We also performed an attempt to encapsulate bioplastic between two spoons to cure.

Cracked gypsum mould

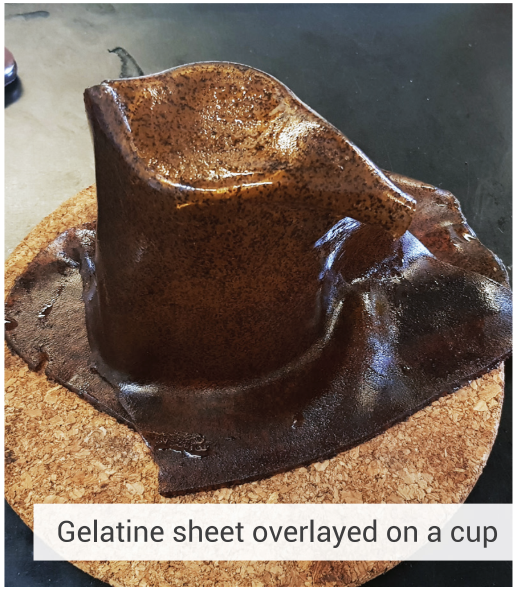
Our first experiment identified the fragility of material when stretched or cut. Hence in the second iteration we focused on how we can use an entire canvas to form shapes. We started by placing material over bowls and plates, letting it dry in this way. This method proved to be more reliable because after placement we didn't need to adjust the plastic.

LIQUID

When liquid, bioplastics can take any shape they are poured into. They thus offer great flexibility with creating irregular and organic forms. To take advantage of this flexibility, we made two rectangular moulds sized to fit a regular kitchen spoon. Our intention was to create a two-part mould, one part for the top and one for the bottom of the spoon. To avoid plastics, we used gypsum, over silicone, as a material. We poured the first mould and waited until it was sufficiently hard to hold the spoon, then placed the spoon inside. It was extremely difficult to place the spoon correctly. Aligning it was hard. It tended to sink into the gips, and due to the curved shape of the spoon, which we hadn't accounted for, displaced gips overflowed the mould. Once dried, it was impossible to remove the spoon without destroying the mould. We concluded that gypsum was not an appropriate material from which to cast the spoon.

SOFT

Of the different bioplastics we were working with, starch-based cast the softest form. We used the same method as for hard – we prepared the solution, cast a canvas from it and cut out shapes. We saw that starch-based bioplastic takes a longer time to harden in comparison with gelatine-based. Because of that we decided to reuse left-overs after cutting out shapes. At first, we thought left-overs can be reused, but this was difficult due to the uneven density of the material.



Gelatine sheet overlayed on a cup

PARSLEY GELATINE BOWL WITH A PIE CRUST FORK

Food by: Design School Kolding

4.1 SDU's 50th ANNIVERSARY

During SDU's 50th Anniversary celebrations, we held a research lab in the wild – a participatory event that is both exhibition and research in progress (Wilde, Underwood, 2018). We were also inspired by Max Liboiron's approach to citizen peer-review (https://civiclaboratory.nl). Our aim, during the event, was to evaluate our work in progress by inviting visitors to participate in the evaluation.

The exhibition was conducted around a table that showcased material examples and crafted artifacts. The aim was to enrich the exhibition and start a conversation around availability and practicality of our chosen methods. In addition to exhibiting the materials, we installed a single-plate electric cooker to prepare a gelatine-based bioplastic together with the visitors. While cooking, we noticed that our working process was clearly understood. Many referred to it as similar to jelly making - which also uses gelatine.

Visitors were intrigued and excited about the look and feel of the utensils but at no point did they say they would actually use them. In contrast, the

Exhibition at SDU's 50th Anniversary

examples of food wrapping alternatives were welcomed. It seemed an issue for many people that food wrapping is vastly unsustainable, especially considering that it becomes almost everyday practice in the kitchen. Bioplastic wrapping, on another hand, creates a similar experience to plastic wrapping and it is hyper compostable. Another alternative is bees-waxed fabric, which traditionally was made at home but can now be purchased through online services, like Amazon.

4.2 FOOD+ [material practices], Nordic-Baltic Biomedia Network Symposium

A month after our Research Lab in the Wild, SDU hosted theFood+ [material practices] Nordic–Baltic Bio Media Network symposium, bringing together key actors in bio media from the Nordic and Baltic regions, Germany and Switzerland. The symposium included two days of workshops, discussions and research presentations abouthyper compostable cutlery, bioplastic, microplastics and bio textiles, and related practices. It was a key opportunity for us to present our research to a wide range of specialists in different fields and build upon it with the insights generated during the workshop.

The structure of the workshop was defined in advance. All the logistics were well thought out, and every choice wasmade keeping in mind the path which participants were encouraged to explore. However, afterwards, we discovered details that unfolded in unexpected ways, we thus learned more about event planning. The event began with all participants introducing themselves to each other, their field of work and main interests.

Bioplastic collection

Participants during the workshop

The first part of the day was dedicated to making bioplastics and edible cutlery. The workbenches were set with basic work tools like 70% ethanol and paper towel for cleaning the work surface, a bottle of water, a spoon, two beakers, and one instruction set. In the common area, the participants could find a range of different tools–two single-plate electric cookers, casseroles, an electric grinder, digital scales, and bowls. For cooking and shaping, gloves, silicone and baking sheets, coffee filters and plastic foil were available. There were also a range of edible materials for cooking–both for edible cutlery and making of bioplastics. These were pizza dough, piecrust mix, millet, rice flour, olive oil, gelatine, glycerol, starch, and agar. As additives, food dye, orange peel, coffee grinds, dried herbs, chilli flakes, chocolate chips, or liquorice powder could be used.

Individually or in pairs, people began experimenting and engaging with the materials and ingredients we prepare. They followed our recipes carefully and tried out new combinations and shapes. Though we introduced this workshop as a cutlery creating activity, some participants used the recipes as a base for other products, such as threads for weaving or alternative materials for soft robotics.

The second part of the workshop was a presentation about microplastics by Tau Ulv Lenskjold (see references). People were then asked to find microplastics in sand samples they had brought with them, or collected locally. The venue, SDU BodyBioSoftLab and SDU Makerlab, are in Pakhuset—a renovated freight warehouse that sits, literally, on Kolding fjord. Seawater could thus be collected straight outside.

After a shared lunch at the Design School, the third workshop took place in theDesign School Kolding textile department. The aim was to engage with new material practices and perspectives from the textile domain.

The afternoon began with presentations of sustainable textile experiments by Design School students (see references) and the workshop manager in textiles—Mie Nygaard Thomsen. One of the students, Maria Viftrup, presented her work with bioplastics. To our surprise, she used the same recipe as we did, but with a better outcome. Her material was tougher and kept its desired shape. To this point, we had explored the gelatine-based plastic recipe by adding herbs, flavours or food colouring. We did not change the base ingredients' quantities. Maria advised us to reduce the amount of water to reduce the wrinkling effect when it dries out.

While obvious, on reflection, we had not thought of doing this. The result in our experiments was transformative, as we could control our curing process more.

The day ended with a vegetarian dinner with food by Design School Kolding served on bamboo plates and in our bioplastic hyper-compostable creations. Some participants used their own hand-made edible spoons and were eager to eat from the bioplastic bowls.

REFLECTIONS ON THE INSTRUCTION SETS USED AT FOOD+ [MATERIAL PRACTICES]

The design of the first instruction sets was created in preparation for the FOOD+ symposium. We looked at numerous recipes online to understand their structure and adapt them to our needs. Here, is where our expertise also played an important role. As most of us had followed online recipes, we knew what we choose to do from these instructions, and where we choose to improvise when cooking.

The final recipes we designed had hand-drawn Danish ingredient images (direct copies of the packages we bought from the local stores) to point out the availability and accessibility of the components needed.

The overall design was minimalistic and focused on a home-like feeling to reduce the impression of complicated scientific experiments some recipes might be perceived as. The symposium was our chance to test out the sets. Prior to creating them, we asked ourselves whether a very detailed description is needed or if we could leave a lot more freedom to experimenting. The FOOD+ workshop unfolded differently than we expected regarding the instruction sets.

We gained meaningful insights from observing how people interacted with the sets, how they negotiated the steps and we learned where to make improvements. We noticed that a lot of people were still asking us many questions when the gelatine or starch plastic was cooking and setting. They seemed to be uncertain about how the material should behave throughout its making and needed reassurance or help if the material didn't behave as they expected.

This was one of the first elements that were up for discussion after the workshop. By adding details, such as "expect it to bubble and foam after some time," we assure people following the instructions that they are doing the right thing and reduce the doubt of their practice. What we learned from this experience is that it is imperative to use these sets to acquaint anyone with some ingredients which might seem unusual, such as glycerol, sorbitol etc and how they behave in this process.

Another improvement idea was the use of illustrations of the process as a better demonstration of each step, so people could easily follow and replicate the same experiment by comparing the pictures with their own creation.

During the process of cooking the cutlery, we also noticed that a hint towards how much material each recipe produces would be highly valuable.

All in all, from this experience we had the opportunity to test and co-create better ways to deliver recipes for home-made cutlery and biomaterials to encourage a shift in mentality towards a better, more environmentally-friendly behaviour starting from our daily practices.

Instruction sets used ad Food+ Symposium

4.3 ENGAGING WITH EXISTING EXPERTISE

FIXING BROKEN GLASSWARE

During the first workshop activity one of the participants found a broken pitcher that had the base detached from the body. She later had an idea to recreate an ancient art of Kintsugi - repairing pottery with gold. As a substitute for the gold binder she used gelatine-based bioplastic mixed with orange peel to achieve a golden colour. The solution was applied with a brush to the edges of broken pieces and stabilized with a thread. Instead of using gold or glass to seal the pitcher, they used a canvas of gelatine-based bioplastic mixed with coffee.


Fixing the pitcher


Bioplastic Kintsugi

ENGINEERING WITH BIOPLASTIC

Some participants wanted to hack the curing process of bioplastics. They connected a power drill to a plastic bucket filled with uncured solution. Once switched on, the drill rotated the bucket, creating a centrifuge-alike environment. The idea was to have the material inside cast evenly throughout.

Eventually, the bioplastic hardened, but it was difficult to determine if the approach improved on current practise.

In the reflection session with participants we determined that the recipes needed improving as some important parameters were missing. We added information about physical material properties at different stages of preparation to show what outcome is expected.


Engineering with bioplastic

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CHILLI FLAKE GELATINE BOWL

Food by: Design School Kolding

5 DISCUSSION

In our current times it seems almost impossible to renounce the use of plastic. It is still used in such a broad range of food related objects, like bottled beverages and disposable cutlery, even as packaging for food itself. While the situation is changing—bamboo and other alternatives are increasingly available, our research illustrates the dramatic scale of the waste problem and how humans have lost control over the amounts and types of chemicals we are releasing into our environment and our food. Current research (Barnes et al., 2009) predict increasing pollution due to escalating annual plastic production, if we do not get a grip on the problem.

In this project we approached three different topics:

1. Microplastic collection and filtering

2. Hyper compostable bioplastics

3. Baked edible cutlery

We made our findings accessible in form of clear instruction sets with material samples and use cases. The filter system as well our edible and compostable products can be produced by anyone using DIY methods and store-bought materials to contribute to a plastic free and eco-sensitive future.

We began by reproducing online recipes, trying to understand how the material properties adapt to changes in the instructions. Through several iterations the recipes were improved and tuned to various desired outcomes like hard plastic, rubber and plastic foil. While working out the gelatine plastic recipe we changed the ingredients from approx. 80% water / glycerol solution and 20% gelatine to a 50/50 relation to reduce shrinkage and create hard plastic objects that keep shape while casting. Similar changes were made to the other recipes, to achieve a better outcome, or give much-needed information to the DIY bioplastic novice.

To produce tableware, it seemed to be a necessity to create waterproof materials, contrary to the natural properties of galantine or starch-based bioplastics. Our material tests showed that our products slowly but steadily dissolve when used, for instance, for hot soup. Not so much that the tableware disappears before finishing the food, but the slimy layer that accrues was not pleasant. Indeed it was positively creepy. Material experiments demonstrated that our plastics are suitable to contain organic granulates like orange peel or coffee grounds.

Then we started incorporating herbs and spices that would release flavours to a meal through the dissolving process. Making use of this effect opened new opportunities, designing towards playful gastronomy (Altarriba Bertran and Wilde, 2018).

The outcomes of our experiments, engaging with different dough recipes for tableware and ways of sculpting them, are also contributing to this field. Current research shows that texture and material properties of tableware have a strong influence on the gustatory experience (Spence et al., 2012). We strongly believe that the outcomes of our research can challenge perceptions towards cutlery and the way people engage with it, and open new ways of thinking towards eco-friendly alternatives in gastronomy.

Further, the cutlery design played an important role in this project. The recreation of conventional spoons, forks and knifes caused problems due to limitations with DIY casting methods and the structural strength of the resulting items. To cope with this issue, we focussed on shapes that can be created simply and still meet the functional requirements of tableware.

Our understanding thus shifted from how cutlery must look like historically or according to modern designs, to what cutlery needs to do and possible alternative looks, that achieve greater functionality.

During this project we had the opportunity to organise two bioplastic workshops. One at SDU´s 50th Anniversary event. The other at the FOOD+ Nordic Baltic Biomedia Network Symposium. These were fantastic opportunities to test our instruction sets and test if our methods were applicable for non-biologists. These co-design sessions were not only valuable in terms of exploring new possibilities and use cases for the plastics, they also helped informing our instruction sets, with new insights drawn from concerns or complications during the workshops. An important step in creating clear and comprehensible instruction sets for instance, was to include the reaction of the material.

Even though people could apply all steps from the first set of instructions, there was confusion and uncertainty regarding amounts, shrinkage and moulding methods. All of these issues were addressed with more detailed instruction sets.

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