Institute for advanced architecture of Catalonia

FABRICADEMY

FAB LAB BCN

AMBER GRAIN EMBROIDERY

Growing folklore elements

Root-based materials, wool waste fibers, natural colours & advanced technologies

BARBARA RAKOVSKÁ

AMBER GRAIN EMBROIDERY | Growing folklore elements

Root-based materials, wool waste fibers, natural colours & advanced technologies

CONCEPT & RESEARCH

Barbara Rakovská

PROJECT MENTORING & SUPPORT

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Institute for Advanced Architecture of Catalonia

Postgraduate in Fabricademy, Fab Lab Barcelona

Barcelona, Spain September 2021

Fabricademy final project

BIOGRAPHY

My name is Barbara Rakovská. I finished my master's degree in design at The Faculty of Architecture at Czech Technical University in Prague. I am taking away a lot of inspiration and knowledge from a wide range of technical subjects and I use it in my freelance work. I am particularly influenced by mathematics, descriptive geometry, and physics.

As a designer, I am interested in biomaterials and environmentally friendly products. During my studies, I focused on eco-design, design help and health, especially design that interacts with the human body.

I'm a free art enthusiast who tries to combine art and experiments with functional objects. New materials are a fundamental theme for me. I am interested in an overlap of design into fashion, objects in relation to the body, and jewelry. I believe we can build a sustainable future by designing sustainable products using biofabrication.

ACADEMIC TRAINING

2023 - 2024: POSTGRADUATE in Fabricademy (Campus Fab Lab Barcelona @IAAC) a multidisciplinary program to (re)define the applications of technology in the textile and clothing industry.

2018 - 2021: BACHELOR'S DEGREE in design at The Faculty of Architecture at Czech
Technical University in Prague

2021 - 2023: MASTER'S DEGREE in design at The Faculty of Architecture at Czech Technical University in Prague

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ABSTRACT

The biodesign approach for fabricating textiles using root-based materials is explored in my final project for my Postgraduate in Fabricademy. I experimented with different types of grain seeds, growing media, patterns, and environments. Additionally, I discovered various post-processing techniques, such as colouring with natural dyes, changing flexibility, and applying biodegradable coatings.

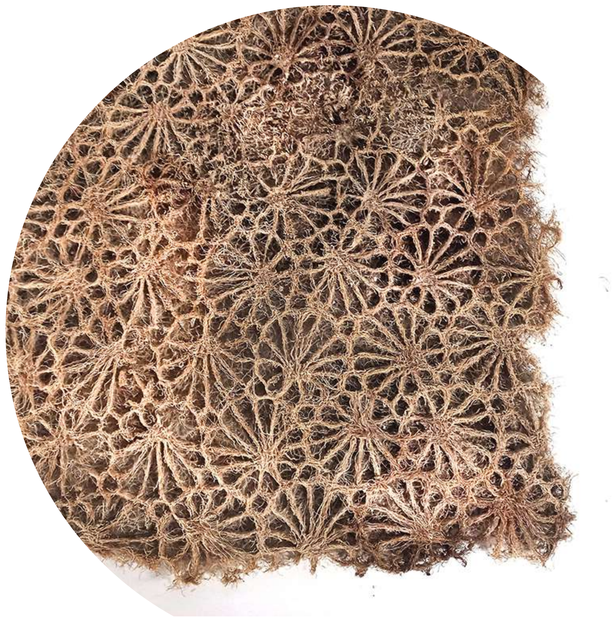
The Amber Grain Embroidery project aims to design bio-folklore costumes featuring elements made of wheat and barley roots. Raw wool is used as a binding agent. The root embroideries are complemented by dried grass and pressed material from seeds. The costumes are inspired by traditional Slovak and Czech folklore costumes, symbolizing the importance of grain as a vital source of livelihood and material wealth. By utilizing root structures in the context of Slovakian folk costume, I was able to blend history and culture with modern technology and nature.

KEY WORDS

Root-based materials / Root embroideries / Bio-folklore costumes / Growing materials / Cultivating materials / Material-informed Design / Digital fabrication & nature / Wheatgrass / Barley

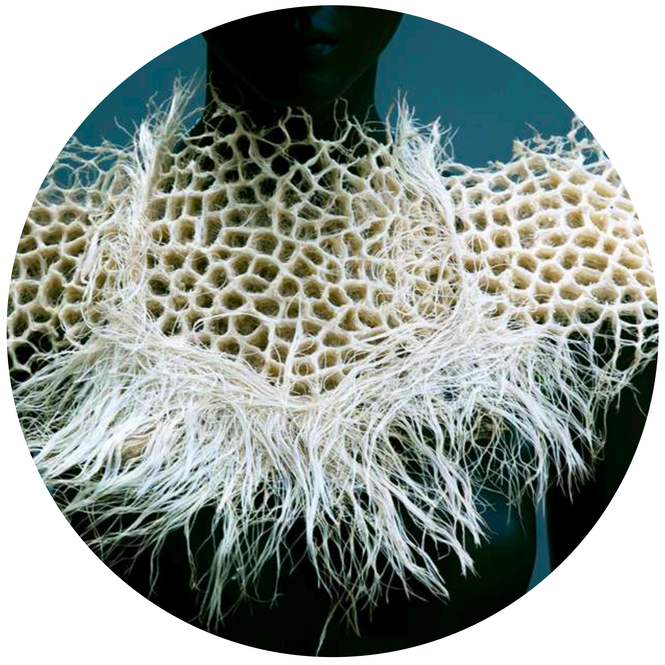
STATE OF THE ART | Existing projects research

There are currently no materials available on the market that are made from root structures. However, some experimental and artistic projects exist.I came across some fascinating projects on the topic that served as an excellent foundation for my research to build upon.



RootSkin - from soil to soil

Roots and architecture



Zena Holloway

Wheatgrass roots

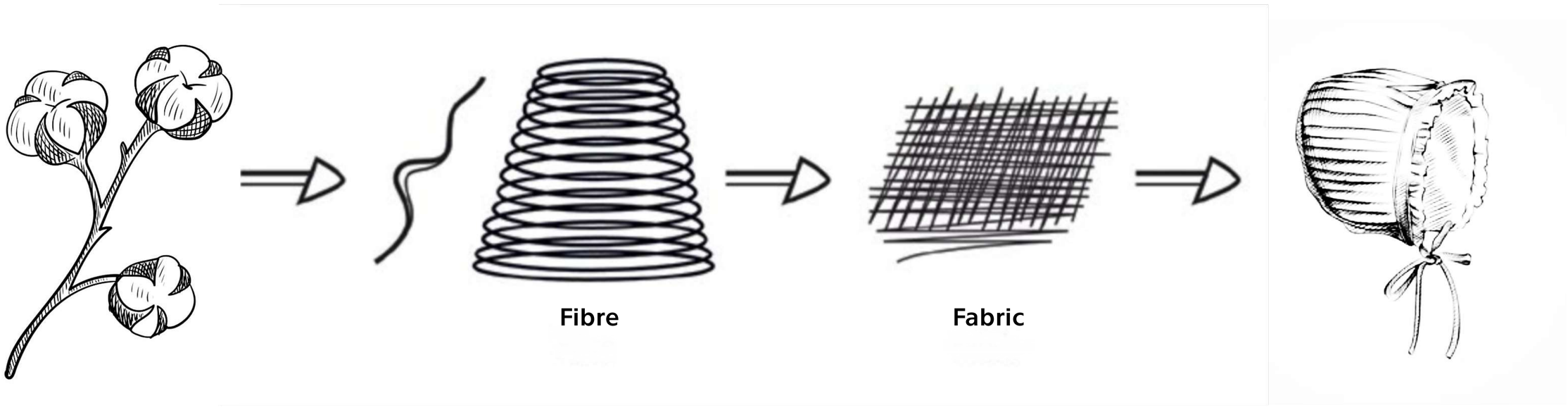
InterWoven - Diana Scherer

Oat plant roots

Naturally intertwined root structure of the wheatgrass, hydroponic cultivation.

BIODESIGN APPROACH | Fabricating textiles

With the Ember grain embroidery project, I intend to communicate the message of using different approaches for fabricating textiles. The roots of plants weave themselves while looking for nutrition and water, but this process occurs through human cooperation, who provide the plant with suitable conditions and respond to its needs. This theme reminds us to pay attention to the cycles of nature, and in return, nature rewards us. The pattern or shape we create to make the fabric allows the plant to grow through it. This approach calls for considering the entire cycle of the fashion product and promoting the idea of working directly with nature.



TRADITIONAL: Key manufacturing stages - cotton plant to final product

NATURE AS A CO-WORKER

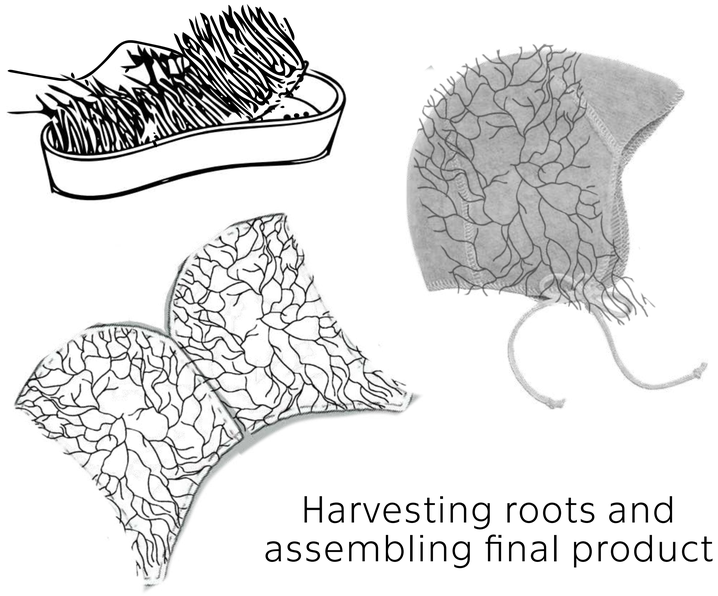
Husbandry principles

Natural nature

Designer = cultivator

Planting seeds

Roots are growing in specific pattern



Harvesting roots and assembling final product

BIODESIGN APPROACH: Key manufacturing stages. The designer collaborates with nature to cultivate and control materials' properties. Plant roots weave while searching nutrients and water.

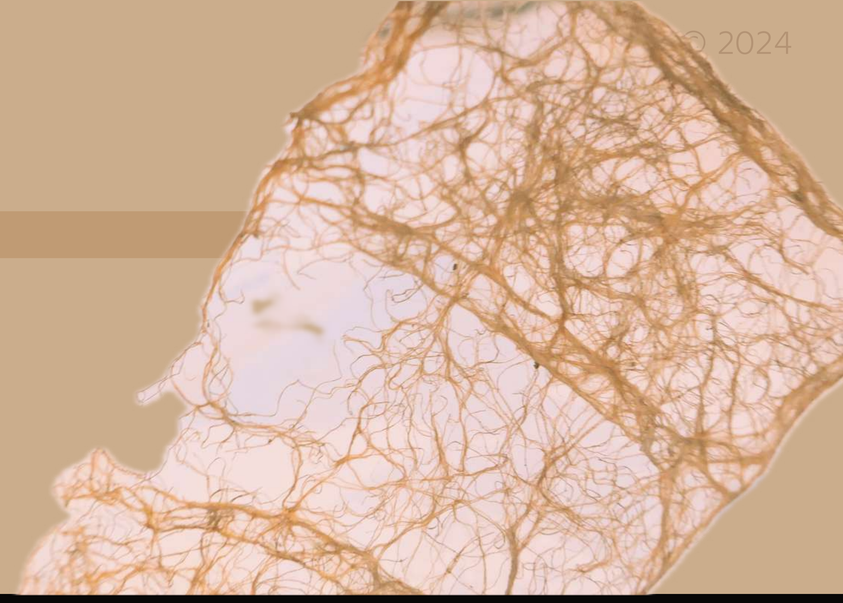
PROCESS | root domestication

Initially, I planned to work with microgreens which consist of vegetable seeds and legumes. However, these differ in their root structure from grasses and cereals. I was studying the root structures of beans, radishes and grass to map the results. After my initial research, I found that wheatgrass and barley might be the most suitable plant for creating root structures.

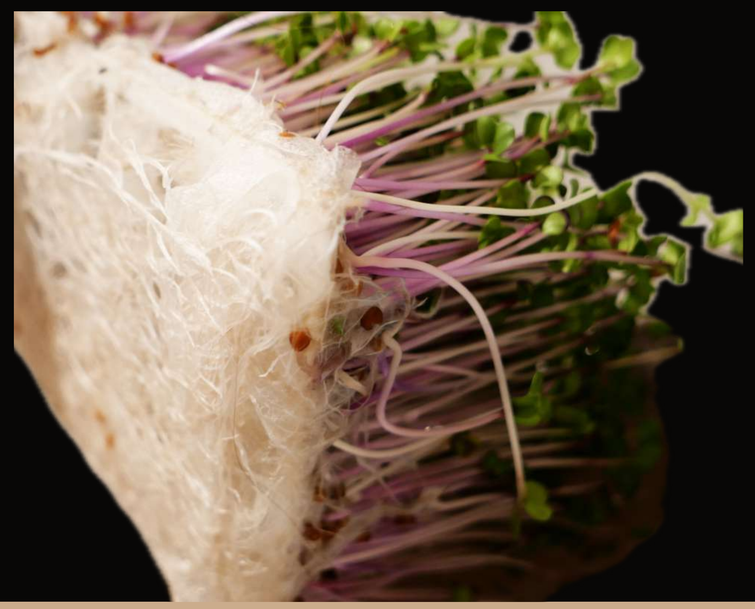
Plants use roots for several essential functions, including anchoring, water absorption, mineral absorption and storage, and transportation of nutrients to other parts of the roots. While the purposes are similar for different plants, there are two distinct root systems based on whether the plant is a monocotyledon (grasses) or dicotyledon (flowers). The **fibrous root system** is found in monocotyledons, while dicotyledons have a **taproot system**. Fibrous root systems are shallower (soil surface) and have a dense network of roots, while taproots have a large main root with smaller roots branching off.

The growth of roots starts when a plant germinates from a seed and it doesn't have a fixed endpoint. This growth happens at the stem's bottom and is driven by the division of cells in the root apical meristems. Roots are made up of cylindrical tissue systems arranged concentrically. These systems are the dermis system, ground system, and vascular systems, from the outside in. At the tip of the root, there's the root cap, which guards the apical meristem and aids the root's advancement through the soil. Above this section, the root's length can be divided into three zones: the zone of cell division, the zone of cell elongation, and the zone of cell maturation. The zone of cell elongation, located above the root apical meristem, is responsible for the root's penetration through the soil. Conversely, the zone of cell maturation is where the cells finish their differentiation. (*Encyclopaedia Britannica, 2023*)

RASS SEEDS FOR DRY AREAS (Bermuda grass), Growth in Agar Agar, Coco coir, very fine oots, fine patterns can be grown in agar



RADISH - fast germination, fragile roots, grey after drying, high water content



BEANS - a little root interweaving, no hair roots, fast germination, good for growing through fabric

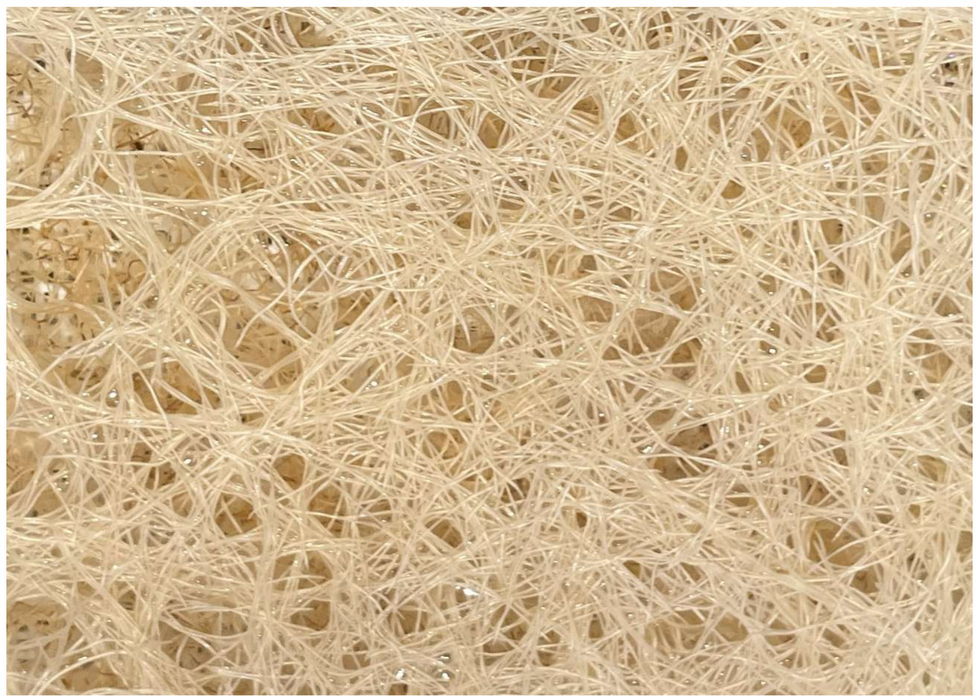
WHEATGRASS | Growth characteristics

Day 1

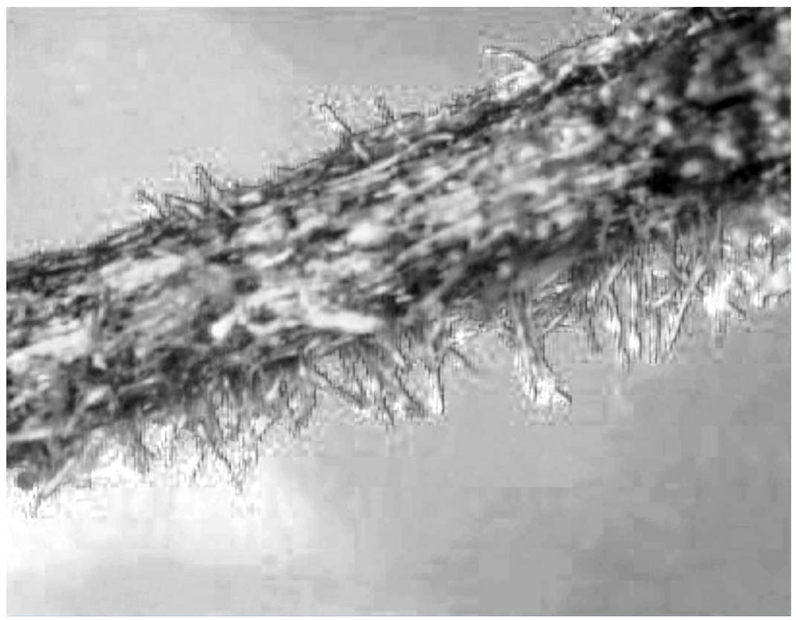
Day 2

Day 3

Seeds are germinated in 3 days



Wheatgrass root density after 11 days, possibility to grow **HYDROPONICALLY**



Roots hairs that create friction between fibers. This friction acts as its own binding mechanism, similar to what is typically seen in non-woven fabrics

I conducted further studies on root structures using wheat and barley. Both plants have fast-growing and tightly packed roots. The properties of the materials are influenced by several factors, resulting in different outcomes. The substrate used for growing the plant affects root health as each substrate provides different nutrients.

One unique aspect of growing root-based materials is the ability to mold roots into any pattern. The pattern can impact both the user's experience with the material and its mechanical properties.

While conducting my research, I also focused on the processing of the residual materials that are produced during the process of harvesting roots, such as grass and seeds. Simultaneously, I described the post-processing methods that can be employed, such as heat pressing, laser cutting, flexibility modification, and the use of natural dyes.

Wheatgrass growth in agar agar,
INGREDIENTS: 4g agar / 1l water

GROWING MEDIUM

- Agar, water, soil, wool

WHEATGRASS

BARLEY

ELASTICITY

- Glycerol
- Boiling / soaking

ROOTS AND BARRIERS

- changing the shape using moulds (patterns)

COLOR

- Natural dyes
- Beeswax

GROWING CONDITIONS

MATERIAL POST-PROCESSING

RESIDUAL MATERIAL

- Grass, seeds

MOULD MATERIAL

-PLA

-Beeswax

MATERIAL STRUCTURE

SURFACE TREATMENT

- Sodium alginate
- Beeswax

ENVIRONMENT

-Humidity, light

-Airflow

CUTTING ROOTS

-Growing fine sheets

GEOMETRY

-Moulds, parametric design

MATERIAL WITH SEDS

-Growing 3D patterns

MODIFYING

-(heat)pressing

-Laser cutting

-Sewing

-Moulding

Dried grass

Fine sheets

Heat-pressed residual
grass and seed layer

3D patterns with
seeds

WHEATGRASS | Understanding growth, ensuring appropriate conditions

Growing 3D patterns

Borders

Agar agar

Growth of fine sheets

Growing through fine fabric

Overgrowing objects

When roots grow in agar, they develop a residual film that enhances load distribution. This creates a solid stucture.

POST-PROCESSING | Natural dyes

Black bean natural dye

Natural color - fine sheets

POST-PROCESSING | Heat-pressing, natural dyes, coating

Natural color - fine sheets

Heat-pressed Mica powders

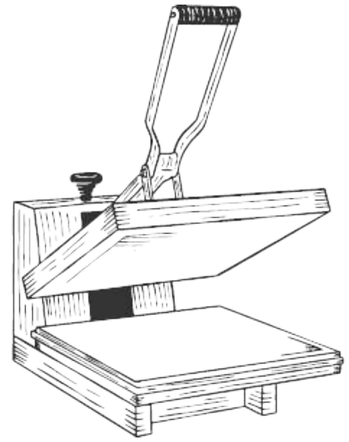
3D pattern with sodium alginate coating, indigo dye and mica powders

POST-PROCESSING | Residual material process

processing of the residual grass and seed layer

by separating the root layer we get fine sheets

cooking with turmeric brine and glycerol



Heat-pressed samples after drying

POST-PROCESSING | heat-pressing, laser cutting

Heat-pressed samples, laser cut patterns,

Heat-pressed sample, laser cut patterns,
sodium alginate coating & indigo dye

AMBER GRAIN EMBROIDERY

Growing folklore elements

Root-based materials, wool waste fibers, natural colours & advanced technologies

AMBER GRAIN | Slavic harvest festival

Wheat is known as Amber grain due to its golden color. This name is also a metaphor for the plant's richness, which offers a multitude of possibilities and materials. Wheat is a grain that is abundant in wealth.

Dožínky - Slavic harvest festival celebrated at the end of the harvest time. Harvest used to be a significant event of the year in areas where grain cultivation was the primary means of income. It was a time when all the grain from the fields had been successfully harvested and stored, and was a cause for celebration! The farmers would thank and reward themselves for the months of hard work in the fields through a harvest festival. This celebration marked the end of the harvest, complete with revelry, where the family would rejoice at the expense of the farmer. The festivities began with the last sheaf being taken from the field. In my project, I utilize wheatgrass and barley, which are some of the primary sources of livelihood. During this celebration, people wear richly decorated costumes.

Harvest wreath - They used all kinds of cultivated grain and very often wove in meadow flowers, Slavic harvest festival

GROWING FOLKLORE | cultural heritage

Lace-making and embroidery have a significant place in the traditional folk culture of both countries. My goal is to bring a contemporary and distinctive perspective to these traditional techniques. These techniques require patience, care, and nurturing, similar to root growth. Unfortunately, nowadays, we often lack the patience and care needed to achieve our goals. I returned to my cultural roots and began researching the elements and essence of traditional folklore costumes.

TRADITION

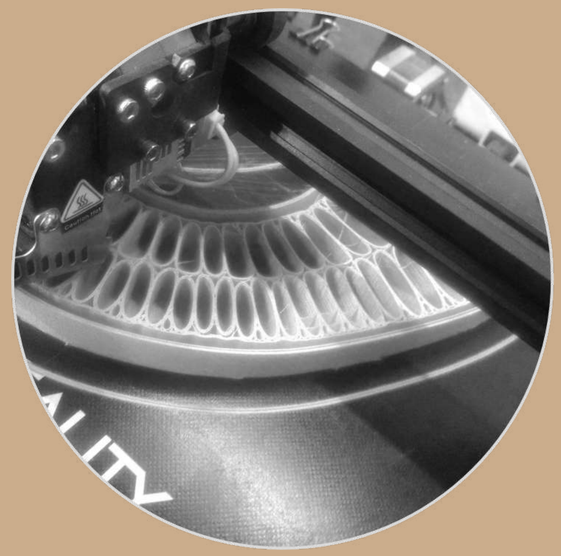
Folklore costume elements

Dožínky - Slavic harvest festival

TECHNOLOGY

Digital fabrication

- Parametric patterns inspired by nature, 3D printed moulds



NATURE

Growing wheatgrass & barley embroidery

cultivating the material under laboratory conditions

TRADITIONAL FOLKLORE | Embroidery, lacemaking

Traditional lace-making

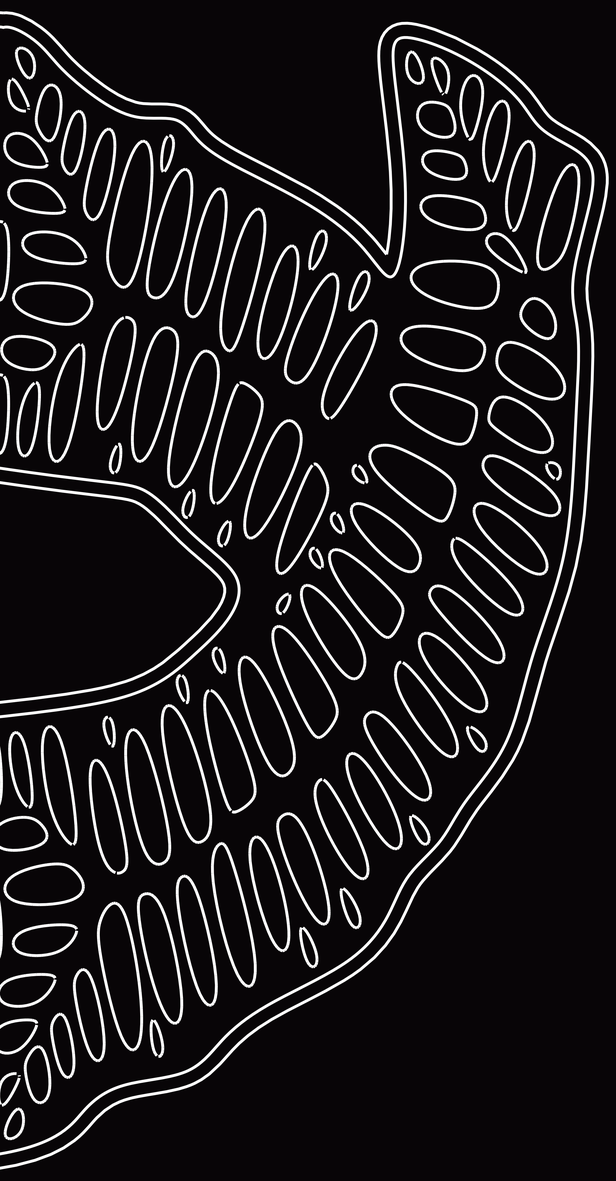
Traditional folklore embroidery

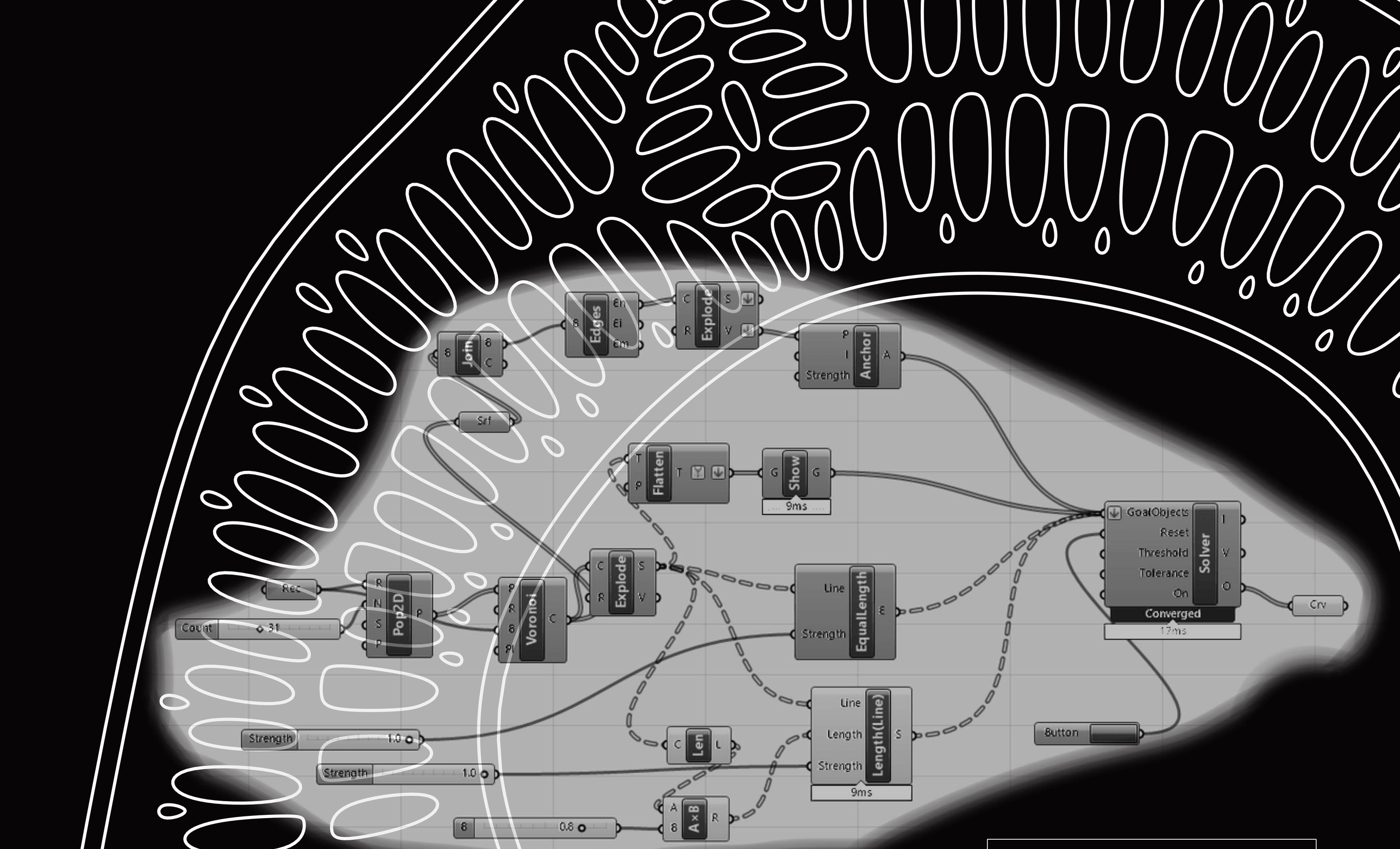
Richly decorated Slovak costumes

PROCESS |
Embroidery cultivation &
advanced technologies

EMBROIDERY PATTERNS | 3D printed moulds

The shape of the patterns is inspired by the anatomy of wheat. I modeled the shapes using Grasshopper.





Using Lloyd's algorithm in Grasshopper to optimize a Voronoi surface.

EMBROIDERY PATTERNS | 3D printed moulds

Parametric patterns inspired by wheat anatomy were created by modifying LLOYD'S ALGORITHM. The Voronoi diagram is still fascinating. I wondered if it could be symmetrical and spread evenly over a surface. After some research, I discovered Lloyd's algorithm. Using Lloyd's algorithm in Grasshopper to optimize a Voronoi surface involves iteratively adjusting the positions of the seed points (generators) of the Voronoi diagram to create a more even distribution of cells.

PROCESS | growing conditions

I used growing lights to cultivate the embroidery within the growing box. Seeds need to be treated against possible pathogens before planting.

Sanitizing seeds with vinegar

1) Prepare the Vinegar Solution: Mix one part white vinegar with three parts water in a clean container. This dilution helps ensure the vinegar isn't too harsh for the seeds.

2) Soak the Seeds: Place the seeds in the vinegar solution and let them soak for about 20 to 30 minutes. This time allows the vinegar to effectively sanitize the seeds without damaging them.

3) Rinse the Seeds: After soaking, thoroughly rinse the seeds with clean water. This step is essential to remove any vinegar residue from the seeds.

4) Dry the Seeds: Spread the seeds out on a clean paper towel or cloth and allow them to air dry completely. Make sure they are completely dry before storing or planting them.

5) Optional Step: If you're concerned about any remaining vinegar residue, you can rinse the seeds again with clean water after they've dried. However, make sure they are completely dry before storage or planting.

6) Storage: Once the seeds are dry, you can store them in a clean, dry container until you're ready to plant them.

Growing conditions

- *Humidity 50% - 60%*
- *Temperature 20 - 22°C*

PROCESS | Harvesting

When the wheat reaches a grass length of 7 centimeters, it's time to harvest. This unique moment is full of excitement as we finally get to see our embroidery.

For this embroidery sample, I used barley seeds and a thin layer of soil to provide better nutrition for the plants. I used a lightweight viscose fabric to separate the soil from the roots.

Once harvested, it's best to dry the roots immediately to maintain their light color and prevent any possible contamination. To dry them, you can use a hot air oven and set it to 60°C. The drying time will depend on the size of the embroidery, which typically takes around 2-4 hours.

- Drying temperature ~ 60°C

- 7 cm grass = ready to harvest

AMBER GRAIN COSTUME | Materials, details

Dried grass and fine sheets

Needle felted pattern to pressed sheet

Cultivated wheatgrass structure in 3D printed mould

Barley embroidery - beeswax mould

Heat-pressed roots with seeds laser cut patterns curcuma natural dye

Raw wool - wet felting

Wheatgrass crown with felted wool base

Wheatgrass roots collar with wheat pattern

wool vest (wet felting) with large embroidery grown in beeswax mould

Barley embroidery decorated belt with wheat pattern

Decorated double layer wool fabric skirt

Felted wool sandals with barley embroidery

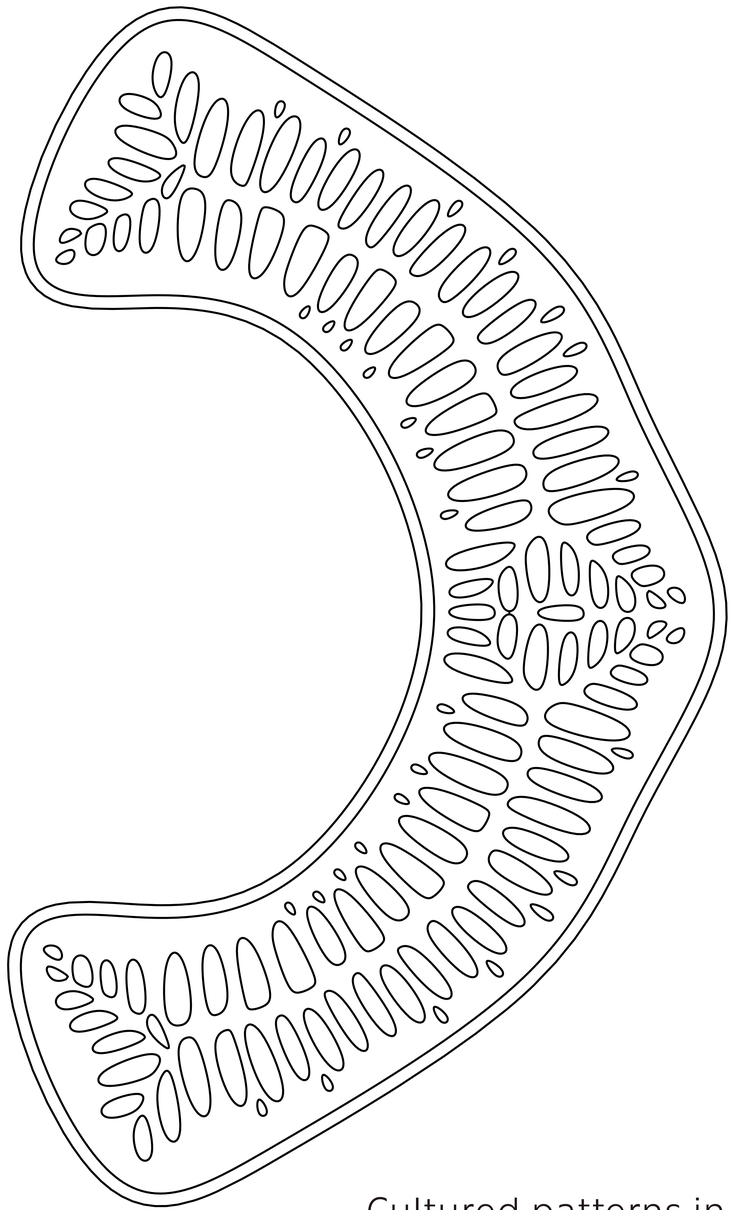
WOOL WASTE FIBERS | Growing medium & garment material

WOOL AS A GROWING MEDIUM | Experiments

Wool is a highly absorbent natural material that can hold moisture better than most other natural materials. This property enables wool to regulate the environment around it, making it an excellent temperature regulator. The breathable nature of wool fibers also allows for good aeration and root growth. Not only did I find inspiration in wool's traditional use in clothing, but I also experimented with reusing the wool growth medium for felting. After harvesting the wool, I dried it and felted it..

Wheatgrass growing in wool fibers, 3 days old sprouts

WHEATGRASS CROWN WITH FELTED WOOL BASE



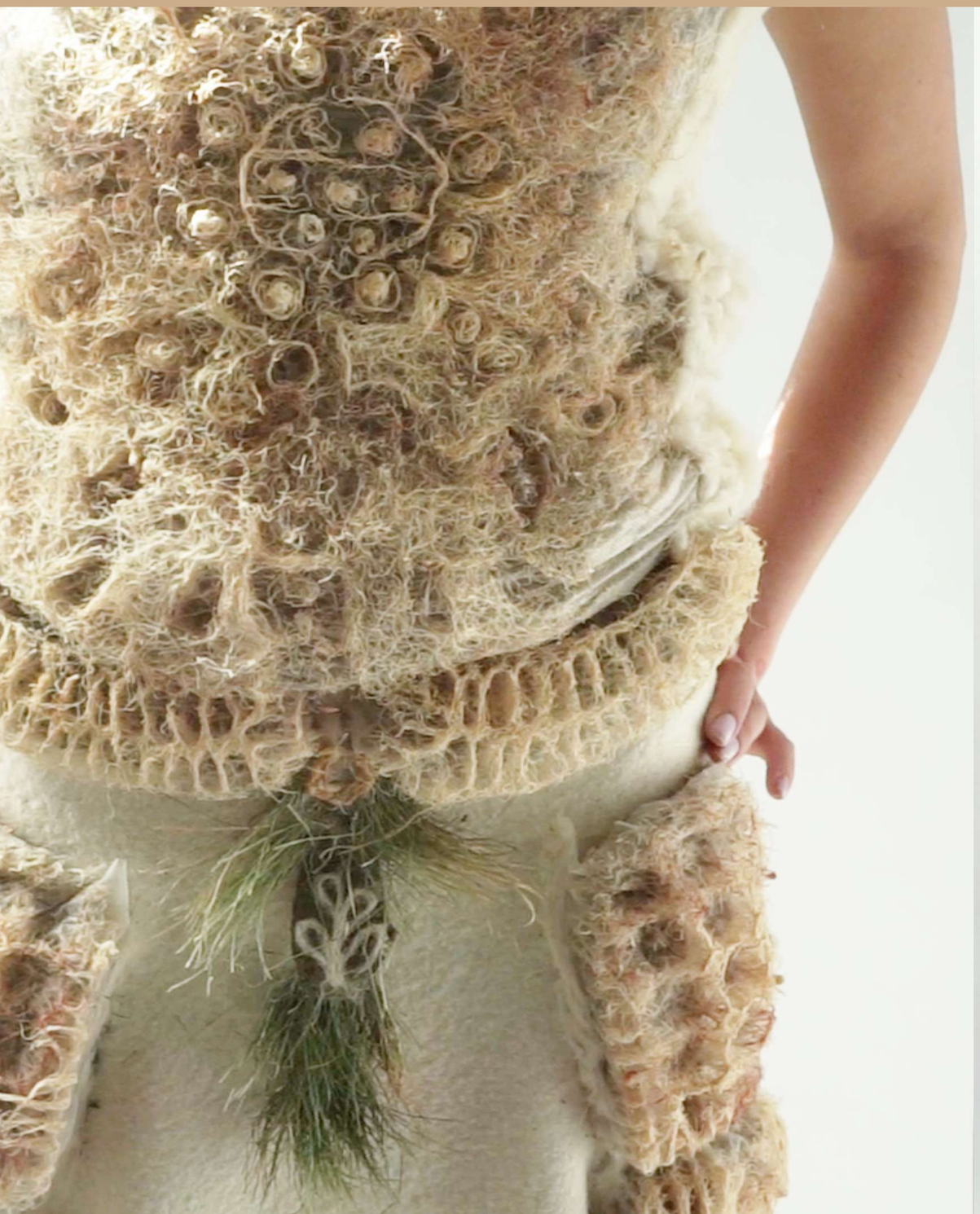
Cultured patterns in 3D
printed PLA moulds

Cultivated wheatgrass
structure in 3D printed mould

Raw wool - wet felting

Dried grass and fine
sheets

Wheatgrass crown with felted wool base, collar, vest



FELTED WOOL SANDALS |
Barley embroidery

GUBA | Traditional coat of woolen fabric worn in eastern Slovakia

GUBA | Coat of woolen fabric

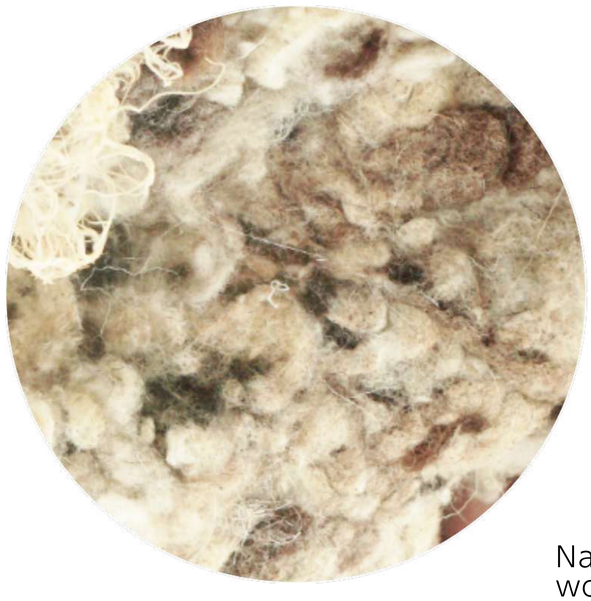
The guba is a type of outerwear made of woolen fabric with a long pile on the surface, mostly worn by men but sometimes by women. It has a simple straight cut with a cross seam at the chest, reaching below the waist, and sometimes below the knees. The guba is draped over the shoulders and tied with a pair of woolen cords below the neck. The neckline is roughly lined with red stitching. It is more commonly found in white, but can occasionally be found in darker colors. The guba was traditionally worn in eastern Slovakia as part of everyday and festive winter clothing. It used to be a compulsory garment for the groom until the beginning of the 20th century.

GUBA | Coat of woolen fabric, elements

Heat-pressed roots with seeds laser cut patterns curcuma natural dye

Heat-pressed sample, laser cut patterns, sodium alginate coating & indigo dye

Barley embroidery



Natural undyed brown & black wool fibers - wet felted coat

CONCLUSIONS

The project Amber Grain Embroidery incorporates a biodesign approach to fabricating textiles, aiming to support eco-design and sustainable solutions in the fashion industry. As a designer, I act as a cultivator who collaborates with nature to control and cultivate material properties. My primary focus is on researching innovative root-based materials by experimenting with different grain seeds, growing media, patterns, and environments. The key principles of the process involve planting appropriate seeds and allowing their roots to grow within a specific pattern or border. The material weaves itself.

Specifically, I am cultivating textile-like materials from wheatgrass and barley seeds. Wheatgrass and barley grains are ideal for root structures due to their dense fibrous root systems and fine root hairs that create binding friction. Through this process, I have discovered various post-processing techniques, including coloring, altering flexibility, and applying biodegradable coatings.

Currently, I am in the experimentation phase and I am seeking to elevate the development of the material to a more professional research level. I have been conducting research on root structures from wheat and barley for a period of three months at Fab Lab Barcelona @IAAC. Additionally, I have sought consultations from various experts, including Robert Thompson, the Scientific Director of Materfad, who provided valuable advice on the potential direction of material development.