Re-Think Potato

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Metropolia

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ReThink Potato – Methods, processes and background of unconventional potato stalk materials as discovered by Innovation course group ReThink Food I.

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Publisher: Metropolia University of Applied Sciences

Editor: Tuiti Paju

Graphic design and layout: Riikka Laaksoharju

Text and images: Tuiti Paju, Riikka Laaksoharju,
Antti Salmi, Linde Lemaire

Publications of Metropolia UAS

TAITO-series 119

Helsinki 2023

ISBN ISBN 978-952-328-398-5 (pdf)
ISSN 2669-8021(pdf)

metropolia.fi/publications

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1. Starting points for the innovation course

Tuiti Paju, Metropolia UAS

Metropolia University of Applied Sciences degree programme curriculums includes a 10-credit multidisciplinary innovation course for every field, with a few exceptions. The course takes place in the first months of third-year studies. The aim of the innovation course is to introduce the students to the concept of innovation, development process management and working in a multidisciplinary team.

The steps in the design field´s innovation course are based on the Double Diamond-design process model (Figure 1), which consist of a background research and design phase. In the first stage of the process, background research is done on the pre-defined theme. Based on the background research, the most interesting topic is selected for further work. At the end of the background research phase, the student group defines a research problem for which the students try to find a solution during the course.

At the beginning of the creative phase, each student first presents ideas to the group members, after which the group together decides the direction of the final project. Service design tools are applied to the design phase of the project, which allows students to test the idea with a target group and to determine how to visualise and to create prototype ideas in an understandable form. Networking and working with stakeholders are characteristic of the design process. The final concepts are tested with target groups and presented to experts.

Student groups practice professional presentation in the three separate seminars, where a multidisciplinary professional team comments on the student group´s outputs at different stages of the process. The aim is to publish the finished projects, for example, in an exhibition or at events related to the theme after the course. The student groups receive support throughout the process from their peer group and supervising teachers. Multidisciplinary groups are chosen randomly. Students are from interior architecture, industrial design, clothing and textile design. In recent years, exchange students have taken the innovation project course as their first course, so the language of the course is English.

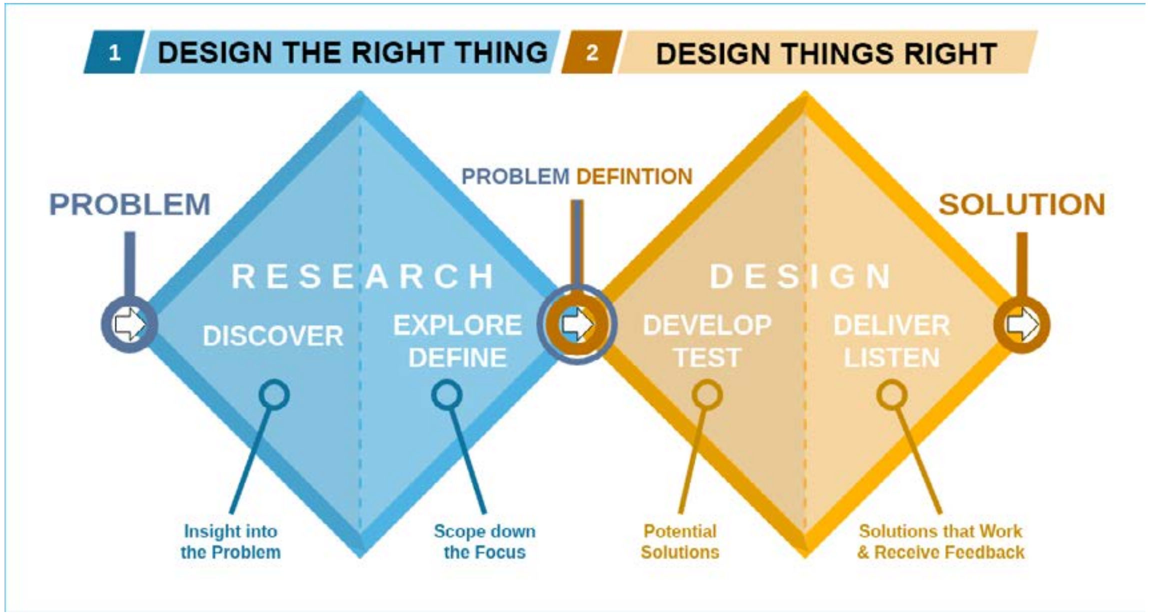


Figure 1: The Double Diamond design process model – Image: Digi-ark

ReThinking Food assignment

In the multidisciplinary innovation project of the Metropolia UAS Design Degree program, student groups are offered several challenges as a starting point for the project. The challenges are often based on customer needs, Metropolia´s projects or topical themes. The aim is to keep assignments as open as possible to allow room for innovation. Megatrends also influence the choice of assignments significantly. Each teacher is responsible for facilitating and guiding several projects.

The World Economic Forum's article: The world's food waste problem is bigger than we thought – here's what we can do about it has listed facts and key figures. Around 931 million tonnes of food goes to waste each year, 61% comes from households, 26% from food service and 13% from retail. Reducing waste could have social, economic and environmental benefits. The UN's sustainable development goal 12.3 obliges countries to halve global food waste per inhabitant in the retail trade and at the consumer level by 2030. (Figure 2). The research question of the ReThinking Food assignment was: What could be the next new and interesting product/ service/ solution/ business in innovative food waste area?

Sustainable development is a megatrend that has been the overarching theme of innovation courses in several assignments over the years. The utilisation of the food industry´s production waste was one of the themes of the innovation course in 2021. In the ReThinking Food assignment, students had to design a service or product concept that utilises the waste generated as a side stream of the food industry.

The following topics were listed as tips for background research: circular economy, food dying, future of proteins, biodegradable materials and 3D printing with organic materials. From these starting points, the groups began their background research and the search for an idea for their concept.

Figure 2: Food waste is a complex issue and comes from a range of sources. Image by Food and Agriculture Organization of the United Nations

Team ReThink Potato

Textile design student Riikka Laaksoharju, interior architecture student Linde Lemaire and clothing student Antti Salmi formed the second of the ReThinking Food challenge student groups. Lemaire was one of the exchange students of the design degree programme, so the common language of the group was English. The group's background research focused on the utilisation of side streams of potato production.

Potato cultivation produces a lot of biowaste, especially in the form of the green above-ground growth of potatoes. How could this material be used in the future? The group's basic idea was to conduct material research on the green parts of the potato and to develop product prototypes from the best materials. The group formed a stakeholder map around the topic. Among others, consumers, a potato grower, a potato artist and a textile conservator were involved in the project.

During the planning phase of the project, the students conducted material research and material experiments. One part of the material research was to look at the fibre obtained from the potato's green parts under a microscope and take pictures of the fibre. Using the laboratory´s aging cabinet, students measured the lightfastness properties of dyed yarns and fabrics under the guidance of a textile conservator.

Material experiments were presented to consumers at two PotatoLab open house events. In the first event, all the samples were on display in the campus textile studio, where consumers could rank them. The best material experiments were developed further. The new material and product prototypes were presented to consumers at the second open house event in a public library. Consumers' reaction was recorded using the same method as in the first event. The answers guided the process forward and proved that the idea was worth taking forward.

Encouraged by the interest generated by their innovation project, Laaksoharju, Lemaire and Salmi decided to put together the ReThink Potato publication, which encourages consumers and the food industry to further process the green parts of the potato to make paper- or colour dyes, or use it as a replacement for plastic, for example. As a supervising teacher, it was a great pleasure to guide the group's work, and I hope that this publication will serve as an example of the circular economy's many solutions for a more sustainable future.

Reference list:

Double Diamond design process model

Metropolia UAS study guide 2023

World Economic Forum *(weforum.org)*

2. Meet the team

Riikka Laaksoharju

is a third-year textile design student and cat owner from Helsinki, Finland. Riikka believes that the world will be saved with traditional handcraft techniques, and some day she plans to own some sheep. Fibre and dye wizard, your local potato farmer, the one with InDesign and the person who asks, “why not?”

Linde Lemaire

is a third-year interior architecture student. This cat-lover is originally from Belgium and when she left for Finland, the last thing she expected from this Erasmus experience was to work on a project about potatoes. She is the scientific correspondent of the group and simply loves working in the conservation lab. Making Excel sheets is one of her many hobbies next to making plastic out of potato leaves.

Antti Salmi

is a third-year fashion and clothing student from the borderlines of instability and genius. Passionate about crafts and space exploration. And a cat lover with a luxury that cats often like him back. Antti is a firm believer in sciences and always happy to participate in , develop and be a part of unconventional projects. His biggest flex is having his name on planet mars, on one of the rovers. He kids you not.

3. ReThink Potato project

Riikka Laaksoharju, Linde Lemaire & Antti Salmi

The design program at Metropolia University of Applied sciences has a time-honoured tradition known as the third-year innovation course. All the design majors are assigned a design challenge to solve in group whose members are chosen randomly. Our group was assigned the task to Re-think food waste and innovate what the next new interesting solution in the food waste area would be.

How did we arrive at the potato stalks?

There are many existing material solutions that utilise food waste. We are already seeing corn plastic on the store shelves, pineapple leather and fabrics made out of banana peels. However, many of these raw ingredients are easily taken care of by our composting facilities in Finland, and diverting from a system that already works well did not feel like the best use of our time.

When we were discussing our project plans with farmers, we got a sense that most of them viewed potato plant stalks as a necessary evil. They are poisonous to eat, so they cannot be used as a feed for animals. Danger of spreading potato blight – a fungal disease that can survive in the soil – prevents organic farmers from simply tilling the stalks back into the field. What if we could use the potato stalk for something useful?

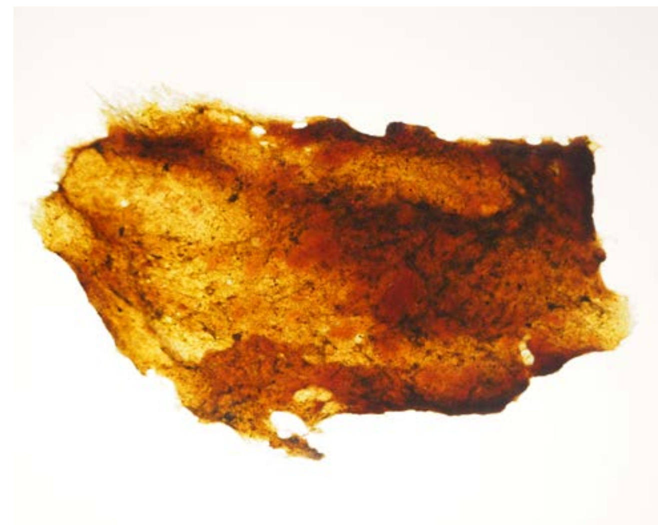
It was a little intimidating to approach the material creation field as a group of design students. During our research, we tried to find reference points that seemed within our reach. Processes that were heavily protected by industry secrets or methods that require specialised facilities were immediately excluded.

Some of our sources of inspiration during the planning stage was an art exhibition by artist Leena Saarinen called *Pollyanna and the Prepper* (2021) and an 2019 Aalto University ChemArts project called *ChemArtsing with Bio-based Materials* that had used tomato plant as a basis for their material testing. We also looked at work done by textile designer Youyang Song, whose work in creating ecological and beautiful bioplastics contributed to many of our aesthetic choices during this project.

We started looking for methods from crafters across the globe who have shared their experiments in papermaking, natural dye, yarn spinning and vegan materials via network of personal blogs. We then sought to develop their recipes further. We also had access to Metropolia's testing facilities that we utilised to the best of our ability. This would not have been possible without the generous help from Leena Niiranen in Metropolia's conservation lab.

The techniques shown in this booklet are still in their developmental stage. We see a lot of potential for further research into the paper, fibre, bioplastic and dye material applications, and have made some suggestions of our own. All our methods are home kitchen friendly and require no special equipment.

This booklet contains the knowledge we gained from eight weeks of research, experimentation and testing. The PotatoLab team feels this is the metaphorical foundation for potato materials, with plenty of possibilities for further development.



Material experiments

4. Fibre

Riikka Laaksoharju

Historically, we have many methods for extracting cellulose fibres from different plants plants – such as linen, nettle, hemp and jute– in order to make textiles.

Some plants are simply better at producting cellulose and growing tall and rigid. Potato is not considered one of those plants, but nevertheless that does not stop us from trying if the same methods work here.

Method

Fibre can be processed using the following method:

Separate the leaves from the stems. Put the stems to soak in cold water for 17 hours, then change the water. Leave the stems soaking for 7 days under a weight.

After 7 days, squeeze the now softened core of the stem out, leaving only the tough fibres on the outside of the stalks. Dry the stems for one day.

Separate the fiber from the dry stems by carefully breaking the stems apart. You will notice tufts of fluff poking out of the stems: this is the fibre. It is very fragile and this phase is time-consuming.

Our material testing did not extend to spinning the fibre into a yarn, though we were told by an industry professional that spinning the fibre should theoretically be possible due to its properties.

Properties of the fibre

The fibre sample was examined under a microscope. It has similar visual characteristics to other bast fibres like nettle and hemp.

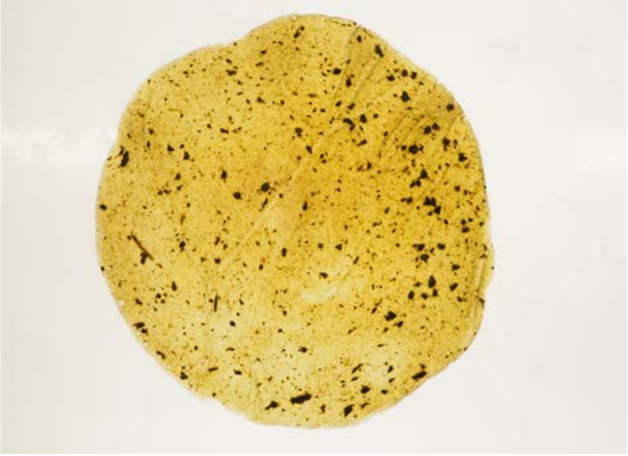
The fibre length can reach up to 3 centimetres, which is theoretically long enough for the fibres to be spun into a yarn.

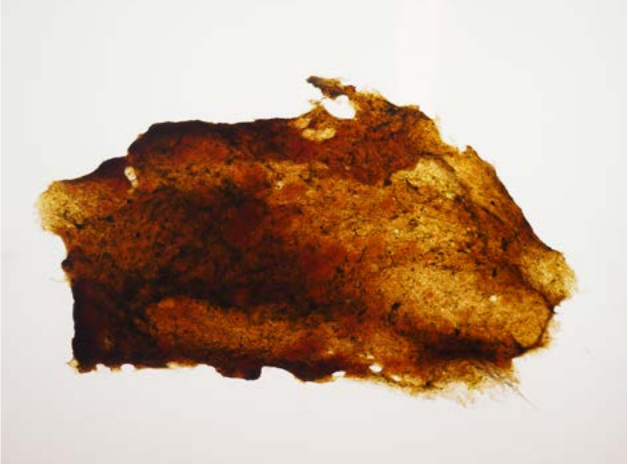
5. Bioplastics

Linde Lemaire

Petrolium-based plastics get a lot of criticism and for a good reason. Especially single-use plastic piling up in landfills and water systems is an ecological disaster that has to be addressed in our lifetime.

Potato leaf bioplastic production is a perfect example of killing two birds with one stone. But it was also one of the methods that was most challenging for us to develop and test. Though the results we got were promising, this is one of the areas that is open for further research.





Methods

We used two different basic recipes to create bioplastic.

For the first method, heat up 6 tablespoons of filtered water. When the water is almost boiling but not bubbling, add 6 sheets or 5 teaspoons of gelatine. Stir the mixture until everything has dissolved. Add 2 tablespoons of vinegar and 2 tablespoons of vegetable glycerine to the gelatine water. Stir the mixture one more time and remove it from the heat. Pour the mixture onto baking paper and let it cool down and dry for 36 hours.

This bioplastic will dry to be very hard and durable. We also found it to be resistant to water splashes but will not survive long periods submerged in water.

For the second method, the most important ingredients are flour and sugar. You start with 0.6 dl flour, 0.6 dl sugar and half a teaspoon of alum. Combine these powdered ingredients and mix them in 4 dl of warm (around 40 °C) over heat. Stir the mixture until it is even. Continue to simmer the mixture and stir until the glue is completely transparent. Remove from heat and pour it onto a baking paper to cool down and dry for 36 hours.

This bioplastic has a nice matte finish, but it is more fragile. It only endures small amounts of water.

These two methods are only guidelines, they can be changed according to your own wishes. There is the possibility of adding leaves, using potato pulp or potato water or a mix of potato water and potato pulp.

Images from top to bottom:

1. Sugar and flour plastic with potato water
2. Geltatine with potato pulp
3. Vegan gelatine (vegegel) with potato pulp and water

Properties of the plastic

All our plastic samples are splatter-proof. After 30 minutes submerged in the water, all of the samples could be torn into pieces.

The flour-sugar plastic degraded the fastest in the water, and the gelatine plastic the slowest. Gelatine plastic has a melting point of 60 °C. Vegegel and flour & sugar plastic did not melt even at 100 °C. It was not tested with temperatures higher than 100 °C

Composting test was interrupted by external reasons, so the results are inconclusive.

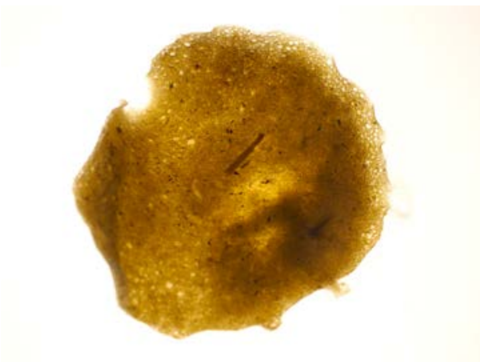
Plastic samples

1. Gelatine with potato water and pulp

2. Gelatine with potato pulp

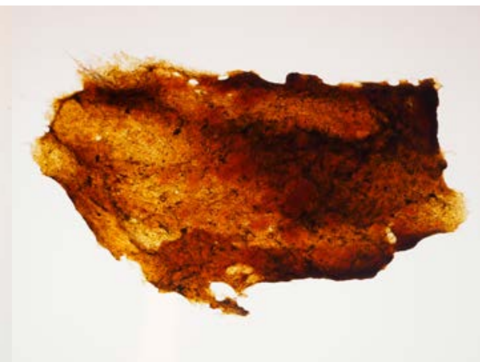
3. Flour and sugar with potato water

4. Gelatine with potato water



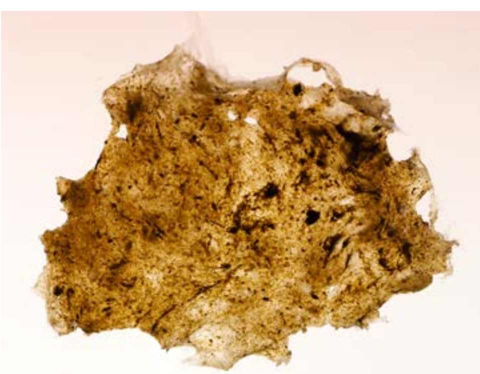
5. Gelatine with potato pulp (whisked)

6. Gelatine with potato pulp



7. Vegegel with potato water and pulp

8. Vegegel with potato water



9. Vegegel with potato pulp

10. Flour and sugar with potato leaves

11. Flour and sugar with potato pulp

6. Paper

Riikka Laaksoharju, Linde Lemaire & Antti Salmi

With only dried potato leaf, egg carton and washing soda, it is possible to produce a variety of materials with different properties.

Varying the ratio of potato pulp to cardboard affects the softness and durability of the paper, enabling a range of different uses for the material. By changing the ratios of the ingredients you get a variety of materials with different qualities. Increasing the amount of cardboard in the mixture makes the mass easier to work with and results in a more bendable material.

Method

Dry the potato leaves for one week. Rip the leaves into flakes and soak in water overnight. There should be enough water to fully submerge the dry plant matter. Bring the soaked leaves to a boil. Before the mass reaches 100°C, add 20% of the material dry weight in washing soda to the mixture. Reduce the heat after the mixture boils, simmer until the plant material is easy to pull apart with your hands. For us, this took 30 minutes. Drain the water and rinse the soda out from the plant mass. Filter most of the water out with a cheesecloth. Beat the plant material into a fine pulp with a hand-blender, for about 5 minutes.

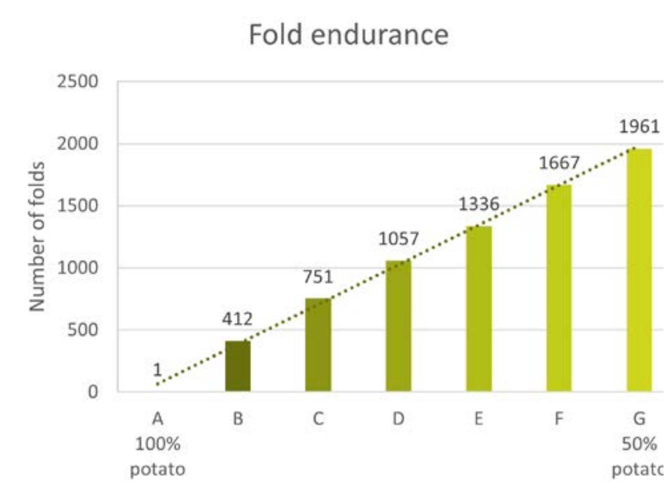
In a wide tub, mix 750 g of wet potato leaf pulp into 6 litres of water. Adding more water results in thinner paper. The pulp should float in the water freely without clumps. If the mass is clumping, blend it more with a hand blender directly in the tub. Pull a sheet of paper with a paper-making mould and deckle, shimmy the mould gently from side to side to lay the fibres evenly on the surface. Let the water drain from the mould. Press the sheet of paper on a mesh surface with the mould and wipe off excess moisture with a sponge. Lift the mould gently, leaving only the paper. Leave it to dry for at least 12 hours.

If cardboard is added, it should be soaked in water overnight and blended into a pulp with a handblender. Add the cardboard pulp in 100-gramme batches and keep pulling sheets of paper from the mixture until you achieve the desired consistency.

Properties of the paper

The fold endurance test is done by bending a corner of the paper back and forth until it breaks off. The number of the folds that each of our samples endured is shown in the graph below. You can see how adding cardboard to the mixture increases the performance of paper samples in the test.

These results allow us to consider practical appliances for our paper samples. Paper that has a high fold endurance can be used for items that are handled a lot, for example maps and bank notes.



7. Dye

Riikka Laaksoharju & Linde Lemaire

The basic method for producing natural dyes is well documented by a large circle of hobbyists worldwide. It also has a long worldwide history: people have been dyeing fabrics using plants and minerals for as long as they have been producing textiles. Guides for producing different colours from nature are abundant.

Yet potato stems have not – at least to our knowledge – been used to dye fabrics before. We tested the method on a variety of materials and recommend using protein based fibres like wool and silk, which retained the colour the best.

Method

Pre-mordant the material by placing it in a pot of water, raise the temperature to 90°C and add 10% of the material's dry weight in alum to the pot. Turn off the heat after 1 hour and let the material sit in the mordant until the following day.

Make the dye bath from the potato stems by boiling the stems for 3 hours. You should have at least 200% of the material's dry weight in potato stalks to get a saturated dye. After the dye bath cools down, add dampened material into the pot.

Heat the dye bath gradually to 90°C and keep the heat up for 3 hours. Leave the material sitting in the dye overnight or for a few days. Rinse thoroughly and dry.

Adding soda or vinegar to the dye will change the resulting colour – soda will produce warm yellows tones, whereas the vinegar will create cool beige tones.

Properties of the dye

Acidic dye bath (pH 1) yielded cool tones and produced a darker colour on silk, whereas alkaline dye (pH 10) resulted in warm yellow hues and performed better on wool. Since the different shades were created by manipulating the acidity of the dye bath, these samples change colour when washed with laundry soap. The colours from the acidic dye bath take on a green tint and iron mordanted samples turn brown.

Dye samples were also tested for lightfastness and they got blue wool grades between 3 and 6, which is a common result for natural dyes. Plant dyes are often less colour-fast than the average industrial dye. The potato dye was subjected to accelerated light aging in the Atlas Suntest XLS+ aging cabinet.

The method of testing was based on Blue wool standard (SFS-EN ISO 105-B01 and SFS-EN ISO 105-B02). For this test, you use eight8 blue wool references. These eight pieces of fabric are each given a score from one to eight, where the blue wool with a score of one has a very low colour fastness and the wool with a score of eight has a very high colour-fastness. You put these blue wool references together with your own sample in the aging cabinet. The aim of this test is to see which one of the eight blue wool samples reacts the same way as your own sample. The number of this blue wool sample is the score your fabric gets.

For evaluating the colour difference you use a grey scale as a guide. Grey scale has five different levels of colour contrast between two shades of grey. You compare the blue wool and your own samples contrast to the grey to see how much they have faded.

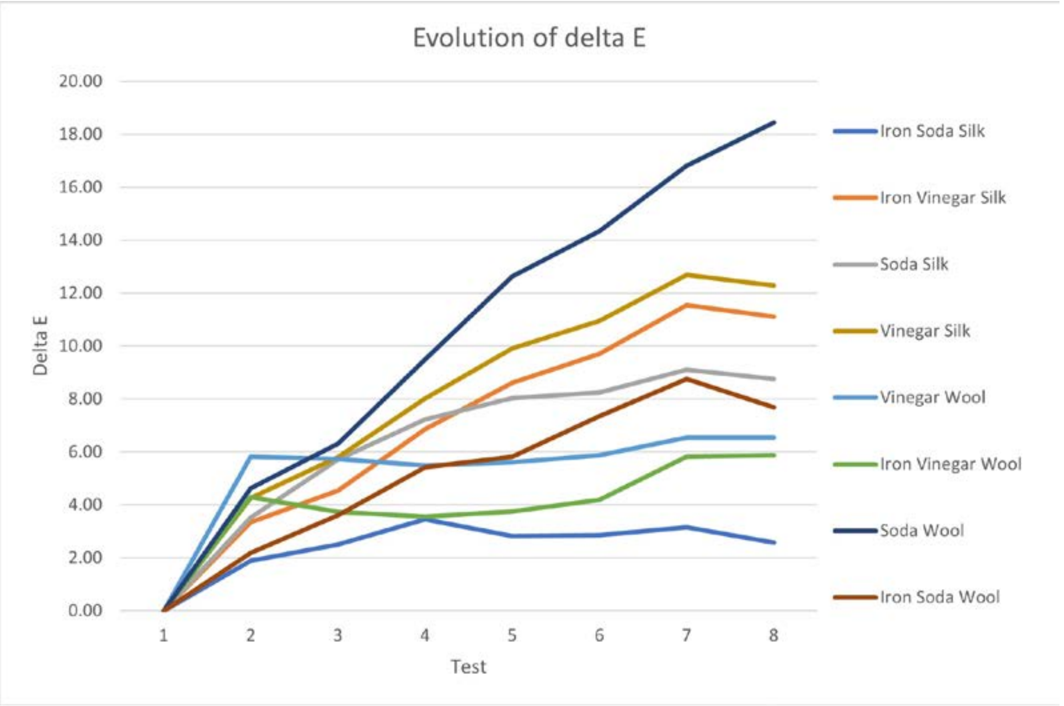
The basic principle of this test can be replicated at home by exposing a part of your dye samples to sunlight for a certain period and seeing how fast the colour will fade.

In the bottom table, you can see the scores our samples had reached in the aging cabinet after 26280.0 kilolux hours. The samples that are marked with an asterisk (*) had not reached a grey scale difference of three by the time the test had ended, so we compared them to the blue wool samples that matched them best when the test ended.

Delta E

Since we began testing the colour fastness, we measured our samples every week with a spectrophotometer. This enabled us to determine the colour of our sample in the CIELAB colour space and calculate the total difference in colour (delta E) throughout the project. Delta E is a numeric value for how two colours appear from each other. If delta E is small, you can hardly tell the difference between the colours, but the bigger delta E gets, the clearer the difference between the two colours. If delta E is 100, it means that the colours are each other's opposites.

When you look at the graph, you can see that the longer the samples stayed in the aging cabinet, the more the colours changed.



Blue wool notes 12.10.2021 Table 1

Material	Blue wool score	Greyscale score
Iron vinegar silk	1/2	3-4
Iron soda silk *	3/4	5 *
Iron soda wool	2/3	4
Soda wool	2	4
Iron vinegar wool	2/3	5
Vinegar wool *	3/4	5 *
Vinegar silk	1/2	4
Soda silk *	4	6 *

8. Ecoleather

Linde Lemaire & Antti Salmi

Taking everything we learned from the previous materials, and through trial and error, we ended up with a material that we were able to develop further into a physical product.

Through a variety of methods, this “eco-leather” can be bendable or stiff, waterproof, shiny, sewable and compostable. In our small consumer survey, most respondents said they would consider purchasing a product made of this material as an alternative for products made from environmentally harmful materials.

9. Prototyping

Antti Salmi

We determined that the ecoleather material was ready to be experimentally developed into some product prototypes.

Based on the sample sheet size, we decided that the product should be some sort of wallet. Since the material displayed similar traits as leather, we tested out different leatherworking techniques and an industrial sewing machine.

For prototyping material we chose gelatine based ecoleather and flour-and-sugar based ecoleather. The two prototypes were named Ransquis and Músee.

Ransquis, which is flour-and-sugar based plastic combined with potato paper, and first cut and moulded into shape. When sewed, it performed like soft cardboard and was sewable by hand. First the seam place was marked and then seamholes were premade with a leather pricking iron. The distance between the holes was 5 millimetres. The seams were then sewn using a saddle stitch. Unfortunately, Ransquis aged poorly, becoming stiffer within months and eventually cracking along the fold.

Músee, which is made from gelatine based ecoleather behaved like chrome tan 3–5 oz. leather when sewn. It could be moulded into shapes without losing its flexibility. It was sewable with a Pfaff 545 compound feed machine which means that in theory, it could be run through an industrial production line. The material has a decent tensile strength, enough to sew a zip onto it. Músee was able to withstand the test of time and is thus a promising material for further testing.

10. PotatoLab Open House

Antti Salmi, Linde Lemaire & Riikka Laaksoharju

Throughout this project we held two open-house events, the first one at the Arabia campus and the second one in Oodi library in central Helsinki. During the open-house events, we collected survey data and discussed our work with peers, outsiders and industry professionals. All in all, 32 people filled our survey.

In our surveys, we asked people to rate our material samples on visual appeal and texture on a scale from one to five, five being the best grade. The survey also had some open questions regarding biomaterials and consumption habits. Those questions were:

Do you use bioplastic?

Where do you use it?

What is your opinion on bioplastics?

If two identical products were on sale in the supermarket, and one of the two was wrapped in normal plastic and the other in bioplastic, would you buy the bioplastic option if it was 5 to 50 cents more expensive?

Most respondents asked for clarification on what we meant by the word "bioplastic." It is possible that ecomaterials have a branding issue. The same terminology is being used for many different concepts. Among materials that are called "bioplastics", we have biodegradable plastics, plastic created from natural polymers, composite plastics and recycled plastic products.

All of our respondents felt very positively about biomaterials in general and wished to see more packaging and product options made from biomaterials in stores.

Results

Our highest-scoring plastic samples were the plastic samples made with the flour- and sugar based formula. We believe that this was due to the material having a smooth matte finish, compared to a stickier gelatine formula.

The highest-scoring plastic sample was the flour and sugar plastic with potato pulp, with a score of 3.69 out of 5.

Out of paper samples, the score tended to rise with the amount of added cardboard, and the highest-scoring sample was the paper that contained 50 % potato pulp to 50% of cardboard. It scored a grade of 3.77 out of 5.

Curiously, sample 4, containing 25% cardboard to 75% potato pulp was second-highest scoring sample with a score of 3.72.

Due to our sample size, it is difficult to draw any definitive conclusions from our survey results. It would be recommendable to repeat the open-house events after producing more completed samples, since many respondents found it challenging to evaluate material samples without knowing their intended use.

Additionally, since the survey were concluded before any material testing took place, we were unable to account for the samples that turned out to be unusable for product development during the testing phase. The highest-scoring plastic sample is not waterproof and gets very fragile as the material ages. This is something we did not realise during the surveys.

Part A

Please rate our material samples according to given criteria on a scale of 1-5.
(1 is the worst grade, 5 is the best)

Test name	Visual apeal	Texture
Gelatin Based Plastic	3.50	3.29
Gelatin Based Plastic + potato pulp	2.67	3.46
Gelatin Based Plastic + potato water	3.08	3.33
Gelatin Based Plastic + potato pulp + potato water	3.25	3.25
Vegegel plastic	3.17	2.92
Vegegel plastic + potato pulp	2.92	2.83
Vegegel plastic + potato pulp + potato water	2.83	3.17
Flour-sugar based plastic	3.50	3.08
Flour-sugar based plastic + potato pulp	3.08	3.17
Flour-sugar based plastic + potato paper	3.33	3.33

Part B

Please choose your 3 favourite colours.

Alcaline (with soda) Silk	13
Alcaline (with soda) Wool	5
Alcaline (with soda) Cotton	3
Alcaline (with soda) Viscose	6
Alcaline (with soda) Iron Silk	2
Alcaline (with soda) Iron Wool	4
Acid (with vinegar) Silk	8
Acid (with vinegar) Wool	9
Acid (with vinegar) Cotton	2
Acid (with vinegar) Viscose	2
Acid (with vinegar) Iron silk	5
Acid (with vinegar) Iron Wool	1

Part C

Please arrange the five samples in order of preference.
(1 being your favourite sample, 5 being your least favourite)

Sample 1	1.57
Sample 2	3.14
Sample 4	3.71
Sample 8	3.00
Sample 13	3.57

Part D

How much would you pay for these objects

Coin wallet	14.69
Envelope wallet	15.56

11. Conclusions

No one can deny that we live in a changing world. As design students, sustainability is at the forefront of each and every project we undertake. The task ahead of us is immense: to change the industry from within for the good of the planet, for the good of all of us.

Working on this project, we ran into many examples of existing biomaterials. It seems that the issue is not lack of sustainable alternatives, but rather the slowness of the industry infrastructure to adapt to new materials. As long as oil-based materials are easier and cheaper to produce and consume than environmentally friendly alternatives, we are unlikely to see any real change.

During the surveys we conducted for this project, the feedback from every respondent was overwhelmingly positive. The consumers are ready for the new materials! Most said they find this sort of research important and were pleased to see the beginning stages, even when samples were a little rough around the edges.

Consumers see these greenwashed buzzwords all the time: environmentally friendly, ecological, sustainable, bio. Many people we interviewed were unsure what these words actually meant, only that they were supposed to be good. This saturation means that anyone wishing to claim any credibility must be ready to show in practice what they are saying in their advertising.

Making most of these samples was not difficult. Some of them may have been laborious, or time-consuming, but few of them required any sort of experience in the field. The methods in this booklet would make good exercises for a classroom or for home exploration, serving as material for craft projects. On behalf of the PotatoLab, we encourage you to try them out.

Due to time constraints, we were unable to do as much testing as would have liked to. We would like to encourage other people to keep making observations about how these materials behave – and what that means for their potential uses.

Finally, we'd like to thank the following people for their help in the different stages of this project:

Our tutor, **Tuiti Paju**

Leena Niiranen for all the help with material testing and standards

Valo Piukkula for logistical services and moral support

Markku Juovi from Pakkalan tila for providing us with raw material and farmers perspective

Leena Saarinen for enlightning discussion about bioplastics

Maria Angwerd for the insight on textile fibers

Oodi Library for providing us with the space to do our survey

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