Politecnico di Milano - Design School

Product Design for Innovation

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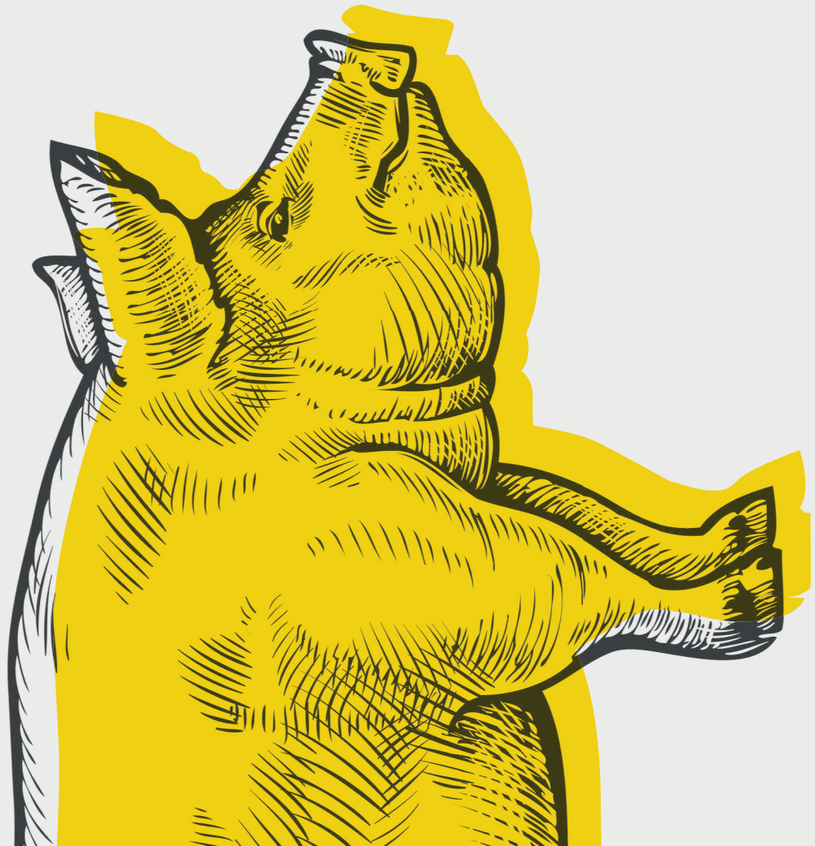
Supervisor: Valentina Rognoli

PIG IT YOURSELF

Developing a new material based on pig skin



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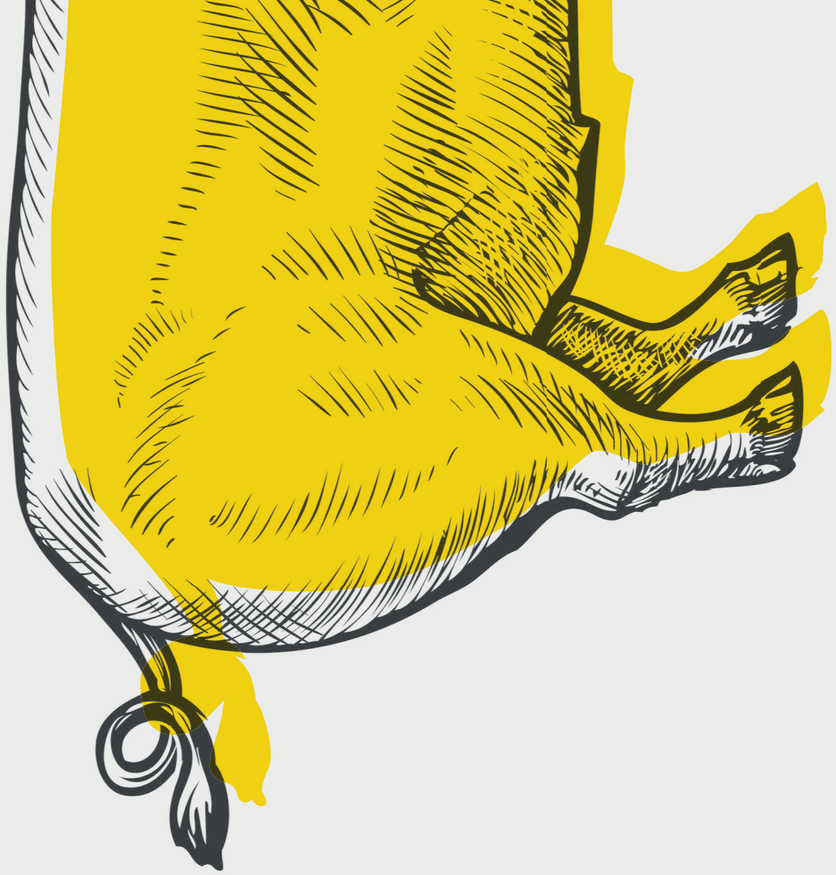

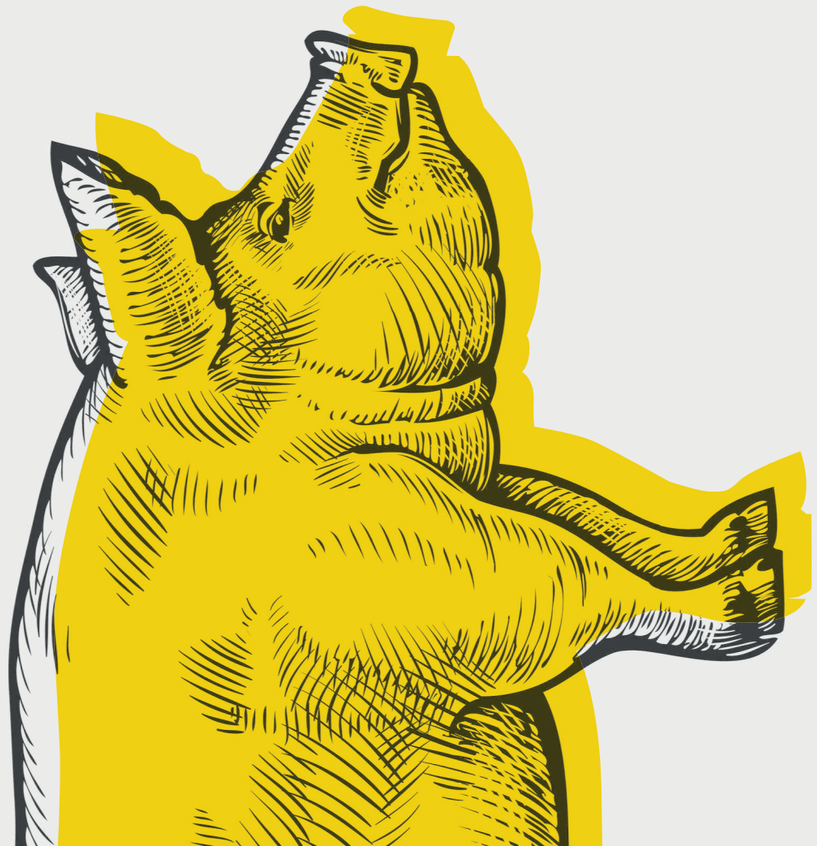

Abstract

La presente ricerca è la mia tesi di Laurea Magistrale, presa sul Politecnico di Milano, e di Laurea all'Univesidade de São Paulo, nell'ambito del programma Doppia Laurea tra le due università. È lo sviluppo di un progetto che ho iniziato al Politecnico di Milano, durante la disciplina di Designing Material Experience, dalla professoressa Valentina Rognoli, che è un nuovo materiale fatto della pelle di maiale. Questo lavoro tenta di presentare l'intero processo di generazione e sviluppo di questo nuovo materiale attraverso il metodo Material Driven Design.

Key Words: Materiale, esperienza, DIY, nuovi materiali, pelle di maiale, animali, sottoprodotti, plastica, bioplastica

Abstract

The present research is the Thesis for my Laurea Magistrale at the Politecnico di Milano and my Bachelor's degree at the University of São Paulo, as part of the Double Degree Program between both universities. It is the development of a project I have started at the Politecnico di Milano, during Professor Valentina Rognoli's Designing Material Experience discipline, which consists of a new material made of pig skin. This work attempts to present the whole generation and development processes of this new material through the Material Driven Design method.

Key Words: Material, Experience, DIY, new materials, pig skin, animal, byproducts, plastic, bioplastic

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00.

Introduction

The democratization of manufacturing technologies, alongside with the public's desire of producing their own ideas, open up a series of opportunities for experimentation in production processes. Individuals are allowed to go beyond the traditional solutions and to develop, by themselves, the necessary tools and resources to create their product from start to end, ensuring the control of all aspects of production, in an effort similar to that of artisans.

In this new scenario, the material – a fundamental part of the product – also becomes an object of research for designers, who have been exploring new possibilities, creating new materials and new aesthetic characteristics. The range of the material is also widened, as it is now selected not only by what it is, but also by what it expresses to us, evokes in us and induces us to do. In other words, by the experience it provides.

With the objective of deepening the approach on this subject, Elvin Karana and other authors have proposed the method called Material Driven Design (MDD).

The objective of this method is to facilitate the project processes in which the material is the main drive. It is divided in four main stages: (1) Understanding the Material: Technical and Experiential Characterization; (2) Creating a vision of the experience; (3) Standards of experience; (4) Concepts of Material/Product. The MDD process starts with a material and ends with a product and/or a more developed material.

In 2017, I had the opportunity of getting in touch with MDD during my stay at the Politecnica di Milano, throughout the module "Designing Material Experiences", under the conduction of Prof. Dr. Valentina Rognoli. Throughout this period, I was able to start the development of a pigskin-based material. The project development had an organic approach, alongside with the discoveries that took place in each stage of the process, and resulted in an exciting material.

The potential and my curiosity on knowing what this new material was capable of offering motivated me to continue the research, and to develop it during my Term Paper for my Laurea Magistrale at the Politecnico di Milano and at the Bachelor Degree at the University of São Paulo, under the double graduation programme I currently attend.

For that, based in the MDD stages, I established as objectives of this new project: characterizing the technical and sensorial profile of this new material, to the best of my abilities, and research possible use and applications scenarios. The following work presents, in detail, the results of this process.

01.

Contexto

The advances in technology, most of the time, have caused great impact in human life, and this is also true for the advent of the Internet and other digital technologies. In a never before seen scale, the Internet revolutionized our way of life, and – conjointly with with computers, smartphones and other smart objects – it allows us to be connected practically all the time, creating, sharing and accessing new information in a quasi-instantaneous way.

This easiness in obtaining and accessing information and technologies has also affected the manufacturing universe, as the access to all kinds of tools becomes more affordable and widespread, and as the internet provides tutorials to almost anything, any individual with an idea is able to manufacture their own product, no matter if in small, medium or large scale, be it through one of several Makerspaces[1] throughout the world, or through their own means.

Those conditions propitiated a more than favourable environment for the appearance of what has been called the Third Wave of Do-It-Yourself (DIY)[2]. The DIY culture is based upon the idea that common individuals can create, build, fix, modify and manufacture an ample range of objects and/or projects with their own hands.

The new technologies and manufacturing methods, combined with the democratization of the means of production provided a new dimension to the production of consumer goods. Before, years would be necessary for a new product to be ready. Nowadays, it takes but a few hours. Creators, designers or makers[3] (as they have been recently named), have total control over the entire manufacturing process of their projects: what used to be mass production becomes self-production.

> **Self-production refers to a way of controlling production processes through experimentation and tinkering: creating a material in a 'lab' and in the same lab, processing the material into a product. (Rognoli et al. 2015)[4]**

Individuals are allowed to go beyond traditional solutions and, through a hands-on mentality, develop the tools and resources needed to create their product from start to end. This experimentational approach grants the control over all aspects of production, almost as an artisan would do.

In this new scenario, materials (a fundamental part of any product) also become the object of investigation and research of designers/makers, who have been exploring new possibilities, creating new materials or endowing materials already widely used with new aesthetic characteristics.

02.

DIY Materials

The Do-It-Yourself movement has expanded beyond the products and affected the materials that shape the product (Brownel, 2015)[5]. By definition

> **DIY materials are created through individual or collective selfproduction practices, often by techniques and processes of the designer's own invention. They can either be totally new materials or modified or further developed versions of existing materials. (Rognoli et al., 2015)[6].**

1. DIY new materials: DIY new materials: those projected through the creative application of unusual substances as ingredients.

Image 1. Alika Bowl. Available at <www.raullauri.com/decafe>

DECAFÉ - Raúl Laurí[7]

Using the reflection on how day-to-day waste can be utilized to its maximum extent as a starting point, Raúl Laurí began experimenting with used coffee grounds. Through a long experimentation process, with patience and enthusiasm, he obtained this material. It is a simple process: it consists in mixing the used coffee grounds with a natural agglutinative substance, and submitting the resulting mixture to a transformative process based in temperature and pressure, through which the material acquires enough solidity to be utilized in a wide range of products.

2. DIY new identities for conventional materials:

This area focuses in new production techniques to bring about new identities for existing materials. In other words, the focus in this case is not necessarily the development of new ingredients, but new ways of dealing with conventional materials.

Image 02. Sea Chair. Available in <www.studioswine.com/work/seachair>

SEA CHAIR- Studio Swine[8]

In a collaboration with Kieren Jones from the Royal College of Art, Studio Swine has created a small factory aboard a ship to collect and process sea debris and transform it a series of stools. The plastic captured in fishing nets or found ashore is classified by colour, chopped in small pieces, and melted at 130º C in an oven. The design is open-source* and uses readily available materials and basic bricolage techniques to allow the creation of the stool.

* Open-source: used to refer to software, etc. that is free to use and can be studied or improved by anyone because it is based on a code that anyone can use.[9]

The idea of creating a new material might seem complicated, especially to those who are used to a more classical approach to project development. However, given the abundance of information on material and manufacturing processes, the beginning is rather simple.

There are several resource and processes sources available, e.g. material libraries and repositories about self-produced materials, such as Open Materials (www.openmaterials.org), where over 100 materials are showcased through a research group dedicated to open investigation and experimentation with DIY production methods. Another such source is the Material Wiki Project (www.materialproject.org), a platform on materials that allows professionals and design students to share their material research and find collaboration opportunities.

03.

Classification of DIY Materials

As explained by Ashby and Johnson (2002), “Classification is the first step in bringing order into any scientific endeavour. The founders of biology, zoology and geology were those who created the classification systems. Classification segregates an initially disordered population into groups that in some way have significant similarities”.[10]

Based in this idea, Professor Valentina Rognoli and her colleagues Camilo Ayala-García and Elvin Karana started exploring the different ingredients sources that compose the DIY Materials, and developed a classification method[11] inspired upon Systema Naturae, the first classification method in Biology, created by Swedish botanist Carolus Linnaeus during the XVII century.

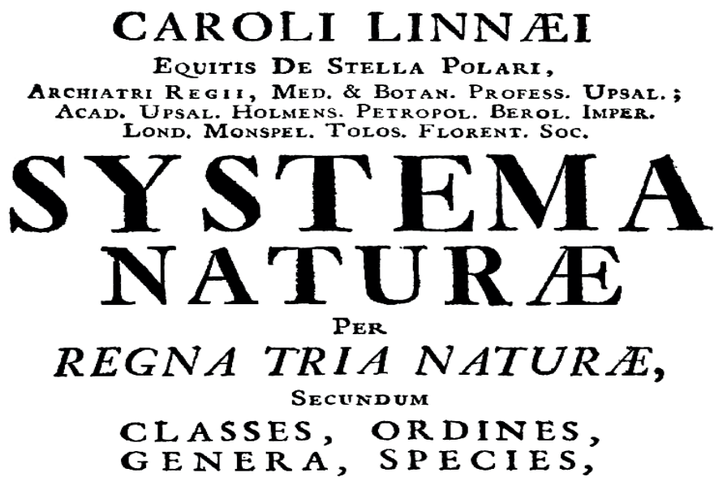


Image 03. Systema Naturae. Available at <en.wikipedia.org/wiki/Systema_Naturae>

Systema Naturae was for many years the standard classification used in biology, in which nature was divided into three great Realms: plants, animals and minerals. Similar to the Linnaeana taxonomy, the classification of DIY Materials is based on the source of the materials and their origins. It is divided into five groups, also called Realms.

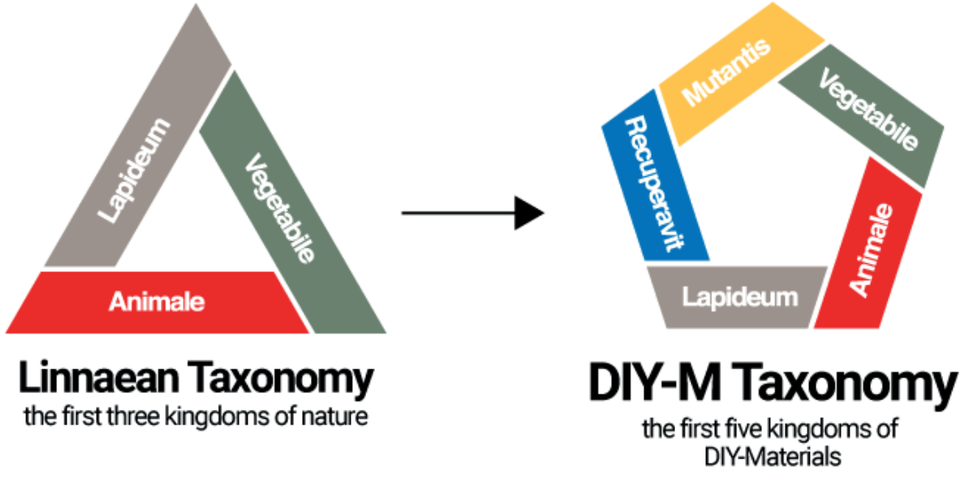


Image 04. Classification of DIY Materials. From “Five Kingdoms of DIY-Materials for Design. V. Rognoli et al, p. 3

1. Kingdom Vegetabile:

Refers to those DIY materials whose main sources are plants or fungi.

SHAPING SUGAR - Amelia Desnoyers[12]

Sugar is a kitchen staple, a solid material that can be easily liquefied and solidified into different shapes. The transformation of this edible product opens up experimentation possibilities in ephemeral shapes and designs. From the chemical reaction of sugar, water and glucose at 160ºC, the mixture offers characteristics similar to those of the glass (transparency, fragility, plasticity, etc). With the glass industry in mind, Amelia decided to join together the melting of sugar and glassblowing techniques to create a new edible design project: sugar cups.

Image 05. Shaping Sugar. Available at <www.ameliadesnoyers.com/Shaping-Sugar-1>

2. Kingdom Animale:

The ones whose main source is derived from animals and bacteria.

BIOCOUTURE - Suzanne Lee[13]

Suzanne Lee describes herself as a bio-couturist. She "grows" her materials from living microorganisms. The method she developed takes its inspiration from kombucha, an acidic drink prepared by incorporating a mixture of bacteria and yeast into sweet tea. The bacteria feed on the sugar and produce a membrane that grows with each passing day. After two to three weeks a material resembling leather, called microbial cellulose, forms and can then be dried, molded, or cut and sewn.

Image 06. Biocouture. Available at <www.livingcircular.veolia.com/en/inspirations/suzanne-lee-biocouture-pioneer>

3. Kingdom Lapideum:

Contains all DIY Materials from mineral origin: stone, sand, ceramics, clay, etc.

MARWOOLUS - Marco Guazzini[14]

Marwoolus, brainchild of Marco Guazzini, is the union of marble and wool. By mixing wool fiber and marble powder into a pulp and placing the resulting mixture in a mold, Marwoolus is born: a hard material, resistant as marble, but bearing the tactile properties of wool.

Image 07. Marwoolus. Available at <https://gucki.it/en/art-design-en/the-marwoolus-anew-innovative-material/>

4. Kingdom Recuperavit:

Refere-se aos materiais cuja matéria-prima provém daquilo que é considerado resto pela sociedade, mas tem possibilidade de ser reutilizado. Na maioria das vezes, eles são plásticos, metais ou lixo orgânico. Algumas vezes, podem vir de subprodutos gerados pela indústria.

EGGO! - Sebastian Aumer[15]

German designer Sebastian Aumer built the “Eggo!” stool using recycled pieces of eggshells. The structure is made out of 70% of this unusual material, whilst the legs are built from scraps of wood. This small furniture piece is entirely biodegradable, since it is made using ecologically correct ingredients only, such as casein, vinegar and corn starch.

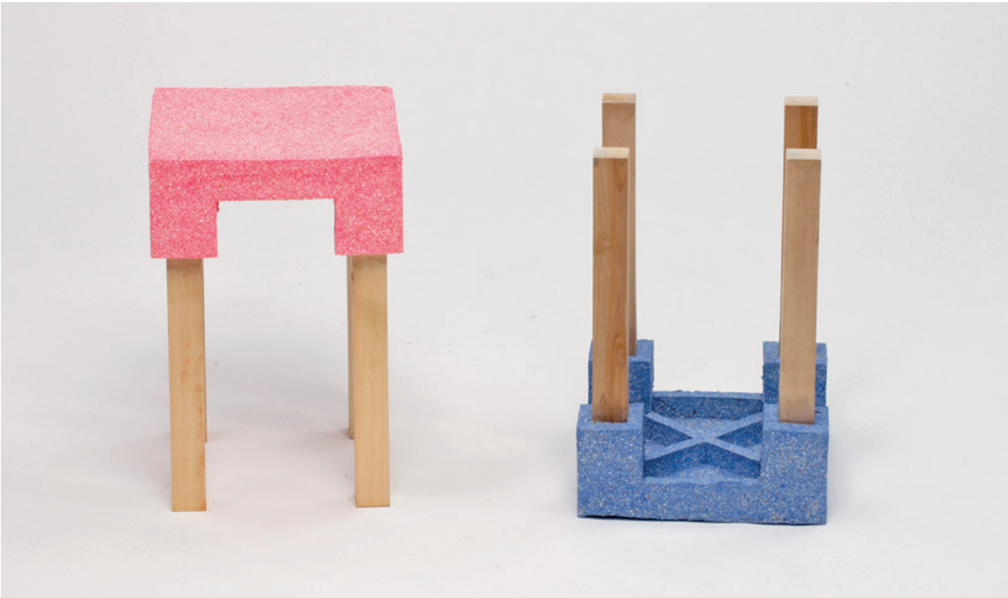


Image 08. Eggo! Available at <https://www.designboom.com/design/sebastian-aumer-eggostool-egg-shells-04-07-2014/>

5. Kingdom Mutantis:

This kingdom contains those DIY Materials created by the mixing of technologies and the hybridisation between interactive and intelligent sources (Ritter, 2007)[16]. The kingdom may also contain combinations from other kingdoms, but always involving some technological source.

MAGNETIC FABRICS - Lilian Dedio[17]

The goal of this project was to explore new limits of fabrics by experimentally developing their natural characteristics through unexpected modifications.

To create these modifications, different aspects of magnetism are incorporated into traditional fabrics. The combination of methodically arranged, magnetically active and passive components causes a mechanical accumulation of elements and thus a dynamic rearrangement of the entire medium. Over and above the original intention to set the fabric in motion, a surprising set of innovative aesthetics was achieved.

Image 09. Magnetic Fabrics. Available at <http://rotterdam.materialdistrict.com/magneticfabrics-lilian-dedio/>

Conclusão

The idea behind this classification is to help providing a starting point to the development of materials and provoke new ideas for possible research, through the analysis and organization of what has been used as source for the development of DIY Materials.

It is evident there is an ample spectrum of possible ingredients for the conception of DIY Materials, not only those from single sources, but also those achieved through the fusion between Kingdoms. Each ingredient brings unique characteristics and qualities to the material being concocted, and at each new combination, something new is learned. In fact, the designer becomes something of an alchemist that mixes and converts certain substances into others, according to J. Lee (2014)[18], some sort of craftsperson able to build and modify the production tools according to their necessities. The DIY approach allows individuals to interact with materials in such a way that each material becomes unique and personal.

This singularity manifests, primarily, through the imperfections on surfaces, typical result of the self-production process. The result of this process is a new aesthetic expression based upon the beauty of imperfection. In Design History, automated processes and quality checks eliminated the possibility of error or imperfection in products. The imperfection is seen as something wrong that must be fixed. Within this new design approach, new relations between materials and products arise, the imperfections of manufacture generate unique results and new experiences in human interaction with the product. This effect stems precisely from the singularity of the materials. Now, the material plays a central role; it is the starting point and the main node of the project.

04.

Material Experience

The material inspires the project: painters paint with paint, writers paint with words, designers paint with materials (Karana et al, 2014)[19], and to decide which material to employ in a project is one of the greatest challenges for a designer.

It is only after the designer chooses the material for a certain product, that the project comes to life. What was once a concept, a description, a bidimensional drawing or a rendered 3d model, now becomes a real three-dimensional object. By picking a material for a project, we make it perceivable by our senses, and this entices others to desire to interact with it, and help create involvement and positive experiences.

So, how must designers choose their materials? There are technical ways, through parameter analysis, such as the selection method by deductive reasoning, which employs the project's technical requirements, paired with the mechanical, physical and chemical characteristics of materials.

However, these technical approaches have their limitations: they do not leave room for the creative usage of any given material, nor of its aesthetic, cultural, emotional, and social dimensions – all of which are of great contribution to a project.

One of the guiding aspects during the choice of materials for a project – and one that takes into account the aforementioned subjects – is the material experience. Materials have a hidden character, even before it is applied; an intrinsic personality, not always readily visible, but one that (when properly handled) contributes to a good project. The perception of said characteristics comes through de interaction with material/product. This, in turn, creates an experience which is a fundamental part of the relationship between user and product.

In 2008, Elvin Karana coined the definition of Material Experience[20], which refers to the experiences people have with and through the material from which a product is composed. It deals not only on the aesthetic value of a given material, but also on the meanings it evokes, and any emotions that might arise during the interaction, how these are felt, and how meanings are assigned to the material.

4.1 The Experience

In recent years, several studies and published papers have been attempting to define two concepts: "user experience" and "product experience". Even though both refer to similar phenomena, there is no consensus. Researchers do, however, agree on the following aspects:

- **Experiences are inherently subjective.** Experiences are brought to life within the mind and heart of each user. Only the user can understand how strong the experience is. However, this does not mean the user is able to put into words what is being felt. Experiences are known for being difficult to explain, since it is challenging to identify where they come from and what are their causes.
- **Experiences related to products (or users) arise from the interaction with a product.** By definition, product experiences are those evoked by the interaction with a product. These might stem from actual use, but also by simulation or the mere thought of a product.
- **Experiences are influenced by personal and contextual factors.** Due to their personal nature, experiences are determined by the users' mind, by their objectives, expectations, dreams and desires. Beyond that, experiences are heavily influenced by the context of use, and by scenarios in which the interaction with a product is taking place.
- **Experiences develop and change with time.** Depending on the duration of the use of a certain product, the experience does not remain constant. During use, users' humours and expectations tend to vary. Therefore, their experiences might easily differ in different moments of the use.

4.2 Types of Experience

Studies show it is possible to distinguish three types of experiences: those related to the aesthetics, those related to meanings, and those related to emotions. The first one refers to how much an object pleases the senses. The second encompasses the characteristics usually attributed to the object (smooth, soft, rugged, cold, etc). The third one arises from the emotions evoked by the object (happiness, sadness, enthusiasm, frustration, etc). Most of the times, the three types overlap in the composition of an experience, rendering it laborious to distinguish those three dimensions.

Aesthetics of Materials

As mentioned above, "aesthetics" is hereby used as a synonym for "pleasing/displeasing to the senses". Anything can be aesthetically appreciated: even materials have their own aesthetic value, and can be pleasing or not. It is part of human nature to attribute sense and value to things we encounter, and determine what is good or bad for us. Therefore, we learn to evaluate aesthetically the objects and their characteristics.

Emotinons

Emotions are provoked by events and situations, be them beneficial or prejudicial to an individual. When the user interacts with an object, an emotion is elicited.

As much as objects, materials can evoke emotions. The purpose of a material could be to surprise the user, for instance. In this case, it would be possible to break expectations, by employing a material with a tactile sensation that mismatches its visual appearance.

Materials Meaning

Many times, we grant products and their materials a significance, and frequently there is a tenuous and diffuse separation between the significance of the material and that of products made from it. We must keep in mind, however, that materials do not have an intrinsic, objective value: it depends on context, feelings and situations of use.

Take wood, for instance: when we say it is “warm”, we might be induced to think it refers to a material property, although it does not. “Warm” is a label attributed to wood, within a particular context (inside a building, for example). These are meanings attributed according to our personal experiences.

Following this example, since wood is usually warm to the touch, it has been universally portrayed as inviting and cosy, in opposition to metals that, due to their coldness, are perceived as distant. Other examples could be rough materials (perceived as being more natural), or thinner, more translucent materials, whose delicacy might suggest frailty.

The significance of materials is inextricably linked to their context: cultural scenario, historic moment, it all can influence the attribution of meaning to a material. We can, therefore, affirm the meaning of a material can change over time (e.g. plastic, once considered cheap and shoddy, is extensively used nowadays).

4.3 Sensorial Perception

We interact with the world through our senses. The same is true for our interaction with products. Usually, the characteristics of a product perceived through the senses are the ones originating from the properties of the material: the visual perception includes the colour of the surface, brilliance and pattern; tactile impressions include weight, temperature perception, hardness of the surface, softness and elasticity of the material. Besides, both vision and touch can perceive the superficial texture and characteristics such as coarseness. Audition, in turn, can perceive the sounds emitted by the material, as well as the surroundings’ acoustic response to the sounds produced by the material. Smell and taste depend on the material’s composing molecules.

It is possible to distinguish two types of material properties: intrinsic and extrinsic. The first one refers to those properties that belong to the material and do not change in constant environmental conditions. These are: mechanical properties (yield, elasticity, etc), physic properties (density) and thermal properties (electric and thermal conductivity).

Extrinsic properties do not depend on the molecular structure of the material, but on its macrostructure. These properties depend on the environment in which the material is employed or the product is inserted. A nice example would be the surface finishing: the treatment dispensed to the surface might be perceived differently depending on environment and lighting.

When we interact with a material/product, all these small perceptions produce an unique experience, and it can be positive or negative. The understanding of how the characteristics of materials reflect on sensations through the senses assists designers in elaborating meaningful experiences. This way, by using the senses and the reactions elicited in them, designers have the ability to create the personality of a product.

05.

Material Driven Design

Under this perspective, materials also generate meaningful experiences for the user, going beyond utilitarianism. A material is qualified not only by what it is, but also by what it does, what it expresses to us, what it evokes in us, and what it induces us to do. However, many of the studies on selection of materials focus almost exclusively on merely practical questions, on how to select the substrate based on shape, requirements and the limitations of each productive process. The possibility to project an experience starting from the material has been, thus far, severely underexplored.

In 2005, Professor Elvin Karana and her colleagues Baharet Barati, Valentina Rognoli and Anouk Zeeuw Van der Lann proposed the Material Driven Design (MDD)[20], a methos to design Material Experiences. This method is experience-oriented and aims to facilitate the processes of the project in which the material is the main driver. There are three scenarios in which the Material Driven Design can be applied:

[Scenario 01]

Designing with a well-known material (e.g. oak, titanium, polystyrene, etc). Even though the material might carry some established significances in certain contexts (e.g. traditional, cosy, high-tech, etc), designers can seek new areas of application in order to evoke new meanings and project new experiences.

[Scenario 02]

Designing with unknown materials, alongside a fully developed sample (e.g. D3O*, thermochromic materials, etc). It is unlikely the material already carries established significance, what grants the designer the opportunity to define areas of application and to introduce new user experiences, identities and new meanings.

[Scenario 03]

Designing with a new proposed material, presenting semi-developed or exploratory samples (e.g. composites from food waste, living materials made from bacteria, 3D printed fabric, flexible OLEDs, etc). As the material is not yet fully developed (i.e. it is a proposition), there is also the opportunity to define areas of application and to introduce new user experiences, identities and significances.

* D3O (formally "D3o") is a polyurethane energy-absorbing material containing several additives and polyborodimethylsiloxane a dilatant non-Newtonian fluid.[21]

The MDD is divided in four main stages, as illustrated below (Image 10): (1) Understanding the material: technical & experiential characterisation; (2) Creating materials experience vision; (3) Manifesting materials experience patterns; (4) Designing material/product concepts. The MDD process starts with a material (or a proposition for a new material, based upon the three possible aforementioned scenarios) and ends with a product and/or a more developed material.

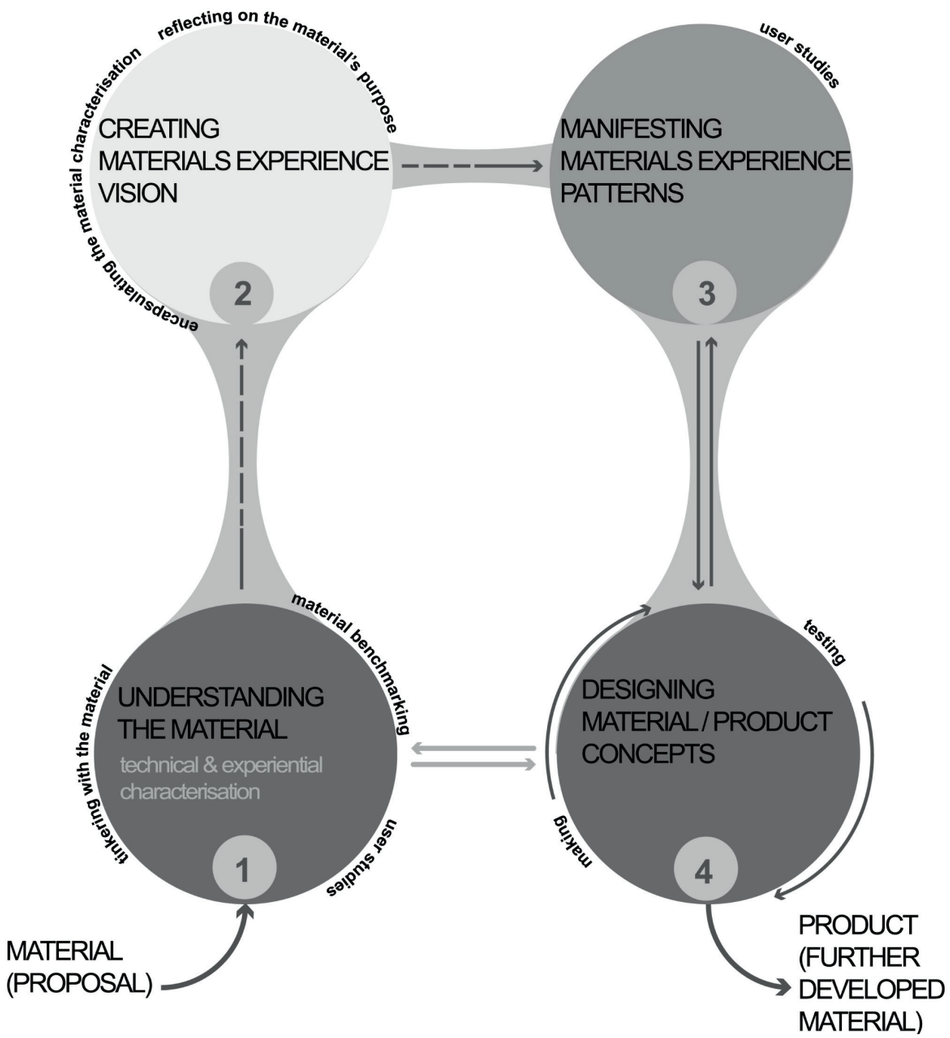


Image 10: Method process for Material Driven Design. Taken from: Material Driven Design (MDD): A Method to Design for Material Experiences. Karana, E., Barati, B., Rognoli, V., Zeeuw Van Der Laan, A., (2015). International Journal of Design, p. 6

5.1 Stage 01: Understanding the Material

In MDD, the designer is expected, first of all, to understand the material at hand and to characterize it technically and experientially. This stage includes manipulating the material, aiming to obtain insights about what it can offer (a process named 'Tinkering'), about its technical/mechanical properties and how the material can be molded/incorporated into products. This stage also includes materials benchmarking, in order to position it amongst similar and/or alternative materials, in a process that can create insights about possible areas of application, and studies involving users, to explore how the material is welcomed by people, how it is evaluated. In other words, experiences related to the aesthetics, meanings and emotions.

Technical characteristics of materials

In the case of completely developed materials, their technical data and mechanical properties can be easily accessed thanks to online databanks. When talking about semi-developed materials, their technical characteristics can be "discovered" through the MDD process.

In any of the cases, however, with or without the technical data, it is essential the designer interacts with the material: hold it in their hands, cut it, burn it, fold it, wrinkle it, combine it with other materials in such a way its qualities stand out, its limitations are defined, and any opportunities of application are underlined.

- What are the material's technical properties?
- Which are its limits and opportunities?
- What are the more suitable production technologies to mold the material?
- Regarding other manufacturing processes, how does the material behave when subjected to conformation methods different from the ones applied?

By the end of this characterization process, the designer is expected to have a clear idea of the engineering of the material (technical/functional characteristics and manufacturing processes) and its limitations.

Experiential Characteristics

Designers must take into consideration the four spheres/levels of experience: sensorial, interpretative (meaning), affective (emotion) and performative (actions). Interacting with the material, creating samples in several shapes and textures and collecting similar materials, the designer is able to understand how the material is perceived by people and which experiences it is able to generate.

- This kind of studies can be conducted through focal groups; questionnaires and interviews, and must seek to answer the following questions:
  - What are the unique sensorial qualities of the material?
  - Which are the most and least pleasing sensorial qualities of the material (according to users)?
  - Is the material associated to any other material due to aesthetic similarities?
  - How do people describe the material? What sort of meaning does it evoke?
  - Does the material elicit any emotion in particular – such as surprise, love, hate, fear, relaxation, etc.?
  - How do people interact and behave towards the material?

The aim of these stages is to establish a map of potential areas of application, and which experiences the material is capable of delivering, according to the fields in which it might be applied.

5.2 Stage 02: Envisioning the Material Experience

In this stage, designers must formulate the intention of design, or Envision the Material Experience. This would be a final objective in the designing process, and summarize the many resulting discoveries from previous stages, in a cohesive way. It expresses how the designer visualizes the role of the material in creating/contributing to the performance and a unique experience when incorporated to a product, as well as its goal when related to other products, to people and to a wider context (i.e., society and planet).

In stage 02 of the MDD method, the designer is expected to reflect on the general characterization of the material, and the questions to be answered in the creation of this application scenario can be listed as follows:

- What are the technical/experiential characteristics to be explored in the final application of the material?
- In what contexts is the material able to produce positive impressions?
- How do people interact with the material within the application context?
- What contributions are to be expected from the material?
- How can the material be interpreted in a sensorial level?
- In an affective level, what does the material elicits in people?
- What roles can the material play for the planet or society?

Once these questions are answered, the designer must be capable of creating an overview of the experience, that might contain elements pertaining to different spheres/levels.

5.3 Stage 03: Finding Patterns in Material Experience

In stage 02, designers were instructed to analyse and group the results of the material characterisation, to reflect upon the purpose of the material, and, finally, to use their intuition and creativity to generate a scenario. Now, to questions to be answered are: which are the interrelations between the created scenario and the formal qualities of the material? What is the shape of the material when the interaction takes place in such a scenario? (Giaccardi and Karana, 2015)[22]. In this stage, the designer is expected to understand how other people experience or interact with the material in the way previously imagined.

It might be difficult, however, to link the scenario to the formal characteristics of new materials and products. In this case, vision and interaction are analysed first, to attain "meanings" (such as "feminine", "familiar", "high-tech", etc, under the interpretative level of material experience), that can be easily operationalized in studies involving users (Karana, 2009)[23].

For instance, a material could have as intent "that people desire to experience it, and get captivated, creating an emotional bond with it". The meanings attained from this interaction could be "desire/tempting" and "emotional bonding". Using these as premise, it would be possible to try to find adjectives that evoke those meanings, such as "provocative" (for desire/tempting) and "modest" (for "emotional bonding").

Bearing those characteristics in mind, the designer's mission now is to imagine how to attach them to the product through the material, in such a way that the meanings of those adjectives can be conveyed; in other words, in a way that the intent/vision of the experience be crystallised in the interaction.

5.4 Stage 04: Creating a product/application

In this stage, the designer groups all the main results found in previous stages, and starts to originate concepts from said results, and from the personal experience in tinkering with the material. In case the project scenario is one in which the material at hand is completely developed, the designer can only work with sensorial qualities through the application of different surface treatments, shapes and production processes.

In the case of the semi-developed materials, the designer is free to manipulate its structure or, in the case of composite materials, they can play with the separated components and create many versions. The final phase of this stage consists in the analysis of concepts and the application of those that, amongst the examined results, were considered the most promising ones for the creation of a product.

5.5 Conclusion

The MDD Method suggests a sequence of steps to be undertaken during the designing process. However, questions pertaining to the nature of a design project itself (production scale, timeframe concerns, budget limitations, redesign of an existing product, for instance) might alter the way in which the stages are undertaken, or the depth in which these are explored, or even result in the omission of one or more stages.

Designers might, for example, skip Stage 02 because, when concluding Stage 01, they encountered some ideas about what would be the concretization of the final material within the provided context. It is their responsibility to explore the "unknown" and stimulate creativity towards new material applications for the future.

06.

Designing Material Experiences

The first part of the present report is dedicated to introduction and contextualisation. Before going into my actual research, I would like to emphasize this chapter to provide a synthesis of the process that led me to PIY. During my time at the Politecnico di Milano, I have had the opportunity to study a syllabus very different in nature to that I have studied during my undergrad studies at the Faculdade de Arquitetura e Urbanismo – University of São Paulo. The modules I enjoyed the most were the ones about Materials.

During third semester, I had the opportunity to take the second edition of the course called Designing Material Experience, under the Prof. Dr. Valentina Rognoli. The main goal of this course was to encourage students to think about the possibilities of projecting from a heightened awareness of materials, and to enrich their knowledge and skills through experiences with materials emerging from the context of the project.

The class, composed of over 50 students from several countries and the most diverse backgrounds, was split into groups, and to each of these one of the Kingdoms of the DIY Materials was assigned. My group was assigned the Animale Kingdom. Alongside the Introduction to the DIY Materials and their classification, we have been introduced to the Tinkering process (part of the first stage of MDD, which aims to understand the material through its direct handling).

MATERIAL TINKERING

Material Tinkering aims to extract data, to understand the properties of the material, its restrictions and recognize its potential. The process assists in obtaining knowledge about materials through experiential learning. Tinkering stimulates the sensorial awareness of material qualities and can reveal unpredictable and unique results as a practical bricolage (Louridas, 1999)[24], and encourages the continuous development and prototyping.

In this process, materials play an active role, suggesting forms of interaction and manipulation. Metcalf (1994)[25] argues that “material speaks”, and the designer must be ready and open to listen to it. Through iterations and adjustments, students establish an emotional connection with the material, enriching their experience with it and through it, developing the pleasure for making.

This method stimulates the students’ creativity and educates them to understand, evaluate and project the experiential, sensorial and expressive characteristics of materials, that is, the concept of Material Experience, Tactile Experience and the Expressive-Sensorial dimension of materials.

Image 11: Eggshells, bones, cartilage and honey

First Experiments

We started gathering all sorts of materials from animal origins to which we had easy access (especially those generally regarded as garbage), in order to explore our possibilities.

Sample.01

INGREDIENTS

Eggshells

Honey

PROCESS

The shells were crushed into small shards and mixed with honey. The mixture was then baked and the baking time affected the resulting material's properties. Through this process, we obtained a sort of pliable, sticky material. The longer the baking time, the less sticky the resulting material, but this characteristic remained no matter how long it was baked. Samples retained a rather pleasing

amber colour, and shiny finish due to the honey. After a few days, it absorbed too much humidity, grew slimier and started melting.

Image 12. Eggshells and honey

SHAPE OF EXPERIMENT

We tried to apply the raw material over eggshells (using these as cast) and baking afterwards.

RESULTS

Due to the shape of the "cast" and to excess honey in the mixture, it melted and slid to the bottom of the eggshell. This way, the top layer consisted of only the bare minimum to hold the small processed eggshell shards together. As a result, the material became much less sticky than the previous sample, but not as shiny. It also did not retain its beautiful amber colour. After some days, just like the previous sample, it also became slimier than when in its original state.

Sample.02

INGREDIENTS

Eggshells Sugar

Glycerine Honey

Vinegar

PROCESS

The eggshells were finely crushed and mixed with the other ingredients. Afterwards, the mixture was brought to a boil and simmered during several minutes.

RESULTS

The resulting material was solid and sticky, and the longer it cooked, the harder it would become. It also presented a darker colour than the first sample, but retained the glossy finish. After a couple of days, it also melted and became stickier.

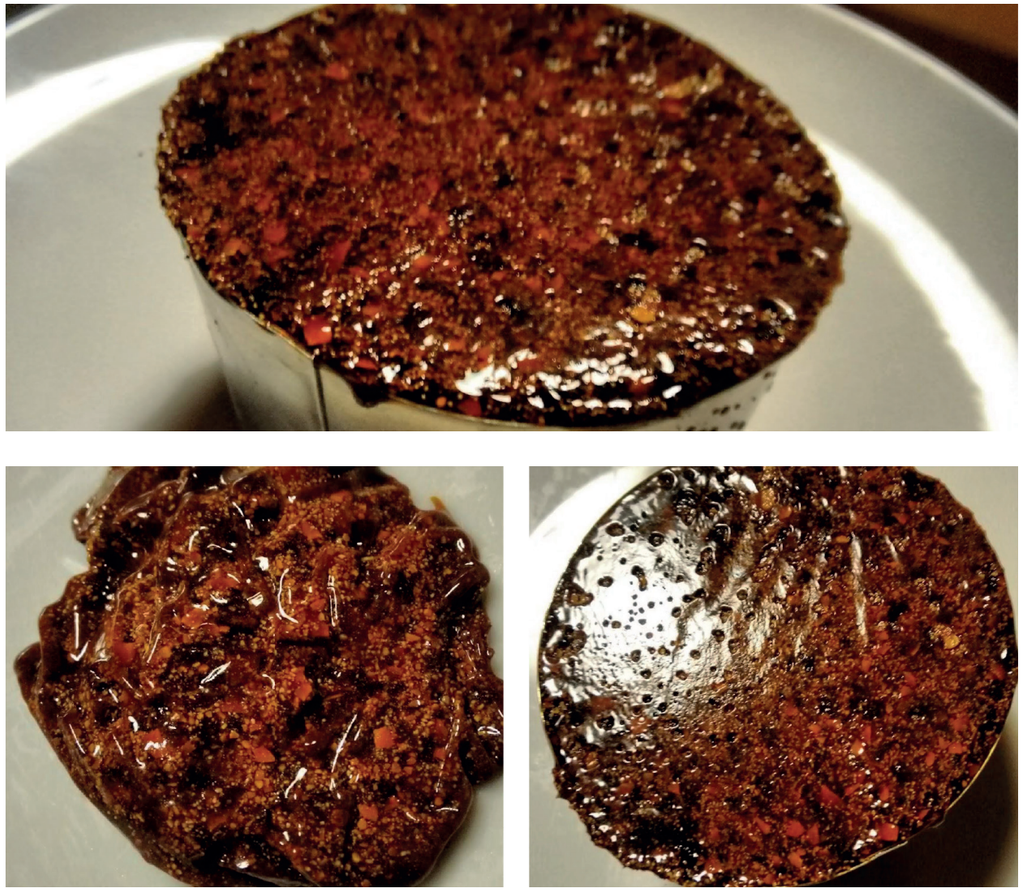


Image 13. Water, sugar and eggshells

Image 14. Pigskin, eggshells and carrots

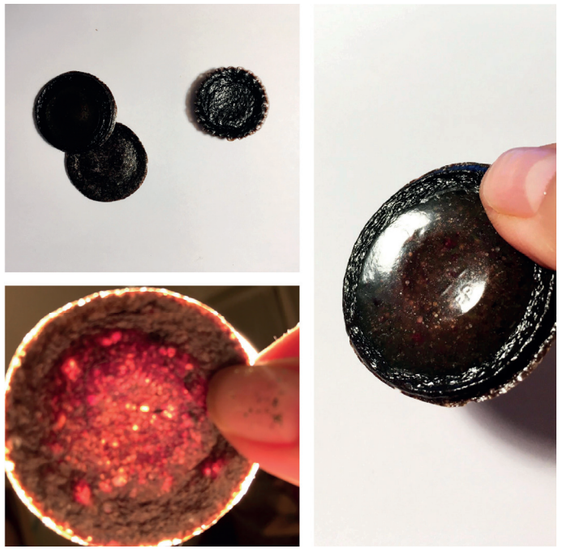


Image 15: Pigskin, beetroots and water

Amostra.03

INGREDIENTS

Pigskin

Beetroots

Water

PROCESS

The pigskin is boiled for around 40 minutes and then blended. It is then mixed with a little crushed beetroot. The mixture is poured into a mold and left to dry.

RESULTS

The material obtained was hard, semi-translucid in appearance and smooth. The beetroots conferred the mixture a slight granulation.

Image 16: Pigskin, beetroots, carrots and water

Sample.04

INGREDIENTS

Pigskin

Beetroots/Carrots

Water

Eggshells

PROCESS

The crushed eggshells were added to the already boiled and blended pigskin. The mixture is then poured into a mold and let to dry.

RESULTS

Appearance is opaque and rather irregular. The eggshells influenced in aspect and hardness, making the material harder than previously and bestowing it with a coarser texture.

Sample.05

INGREDIENTS

Pigskin	Beetroot/Carrots
Water	Eggshells
Milk	

PROCESS

We tried using a smaller amount of eggshells than in previous samples, adding more water and a dash of milk. The ingredients were mixed, poured into a mold and let to dry.

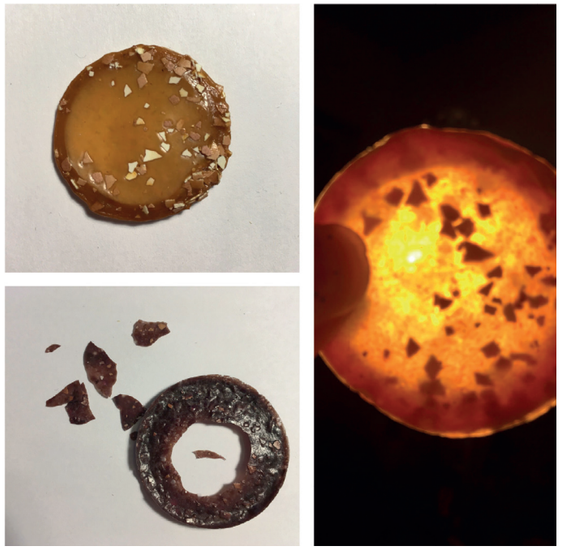


Image 17: Pigskin, milk, beetroots, carrots and water

RESULTS

The material became more transparent. The appearance was semi-translucent, but the excess liquids modified the hardness/flexibility of the material, rendering it brittle.

Image 18: Sustainalize Me – Materiability

Bioplastic

Due to the problems we encountered while trying to develop a cohesive material from the substrates we have been utilizing, we decided to research recipes from other DIY materials, to understand how they work, and if these could be useful for our efforts. The Bioplastic was a perfect example for our purposes, and it allowed us to experiment with different recipes and animal additives.

Image 19: Gelatine, glycerine, water and eggshells

Bioplastic from eggshells

INGREDIENTS

Gelatine

Glycerine

Water

Eggshells

PROCESS

The eggshells were crushed and mixed to the remaining ingredients. The mixture was then heated for several minutes.

RESULTS

The resulting material was a flexible bioplastic. Opaque in appearance and rather irregular, the eggshells play a role in appearance, and do not alter the properties of the material. After a few days, some mould stains sprouted on the bioplastic.

Amostra.06

INGREDIENTS

Corn starch

Raspberries

Eggshells

Water

Glycerine

PROCESS

The crushed eggshells were mixed to the other ingredients. The mixture was heated for several minutes.

Image 20: Corn starch, glycerine, water, eggshells and raspberries

RESULTS

The attained material was a flexible bioplastic. Translucent and shiny in appearance, the eggshells play a visual role, and do not alter the properties of the material.

On the other hand, the raspberries not only awarded the material its pink hue, but also intensified its translucency.

Pigskin x Bioplastic

After testing the bioplastic recipes and experimenting with our own recipes based on pigskin, it came to our attention we got to very similar results, thus compelling us to further investigate the properties of pigskin. This experimentation resulted in the material which is the object of this report: the Pig It Yourself (PIY).

Image 21: Bioplastic from gelatine and eggshells

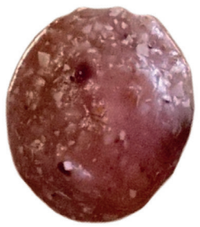


Image 22: Bioplastic from corn starch, eggshells and raspberries

Image 23: Pigskin, eggshells and beetroots

Image 24: Pigskin and eggshells

Image 25: Pigskin, no additives

Image 26: Pigskin and eggshells

Image 27: Pigskin, eggshells and carrots

Image 28: Pigskin, eggshells and beetroots

Image 29: Pigskin and beetroots

Image 30: Pigskin and acrylic paint

Image 31: Pigskin and tangerine

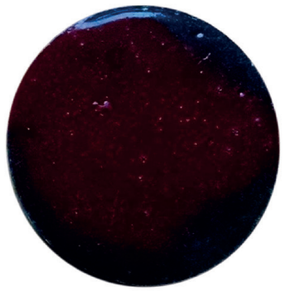


Image 32: Pigskin and honey (the mixture resulted in a material both flexible and elastic)

07.

PIY

7.1 Naming the Material

During the first project, we were instructed to name our material. The name chosen at first was “Porcaria”, for two reasons:

1. “Porcaria” means “low quality”, “badly done”, “cheap”, “sub-par”, and it is used to convey something is bad, worthy of being discarded, both in Portuguese and Italian (TN: It.: *“Porcheria”*);
2. During the process of creation, it seems that it will not yield any good results: the smells, the texture, the appearance, it all appears to be useless. However, at some point, that shapeless substance transforms into a surprising material. It is born from the irony of something that should be, but still is, and it is in its own way, with its own characteristics, and these are what make this unique experience.

3. Por.ca.ri.a

1. Subst. Dirtiness, grime, filth; *2. Adj*. Shoddy, badly made; *3. Interj*. Obscene, vile term; *4. Adj*. Something lacking in quality; *5. Subst*. Any foodstuff or edible lacking in nutritious value, junk food; *6. Subst*. Anything poorly made or lacking in quality.

In this new stage, I decided to name the project in softer way, but maintaining the ambiguous idea: Pig It Yourself (PIY), a mixture between the origin of the material and the origin of the method in which we develop it.

7.2 Motivation for continuing the research

As shown in the previous chapter, the development of the project took a rather organic approach, conjointly with the discoveries that took place during each stage of the process. At the beginning of the project, there was no previous notion of any defined destination. We even questioned ourselves if there was a destination to be reached. Notwithstanding, the trust of our professors in the method, and their enthusiasm in encouraging us to continue the attempts and to keep open to a more experimental approach made us endure and carry on experimenting with any means at our disposal, within the received briefing.

Persistence yielded its results: Pig It Yourself is a surprisingly curious result. People’s reactions while interacting with the material (especially when uncovering its primal matter) were regarded as points in favour of the material, and encouraged us to continue its investigation and development.

Furthermore, this work has a special purpose: it is the culmination and undergraduate paper for the Laurea Magistrale at the Politecnico di Milano, and my Bachelor Degree at the University of São Paulo, under a dual undergraduate programme I currently attend. I also consider the subject at hand to be decidedly appropriate for an integrated undergraduate thesis, given the possibility of bringing these newly discovered methods to my Brazilian alma mater. This makes the research process all the more valuable and creates new and advantageous ties between both universities, which I regard as the main goal of the dual degree programme.

7.3 Aims of the new research

As mentioned, my motivation to keep researching and developing this material stems from its potential and my curiosity on what it is capable of doing. For that, based on the MDD Method stages, I have established these as goals of this new phase of the project: build the technical and sensorial profile of the material to the best of my abilities, and investigate possible use and application scenarios.

Another important topic to be examined in depth is the origin of the raw materials that make up PIY: pigskin, since it is fundamental to the project to find a way in which it can be used sustainably. Therefore, I have decided to better comprehend how the pig is produced, consumed and disposed of.

7.4 O porco

In Brazil, the industrialization of pork production is divided in two groups: the first one is composed of large, market-leading, profit-seeking conglomerates,

making their gains based on scale of production and brand valuation. On the second group, medium and small enterprises, dedicated to specific niches of regional or local commerce: co-ops or family agroindustry presenting great diversity of products[26].

According to the Associação Brasileira de Proteína Animal (TN: Port. “Brazilian Association for Animal Protein”), up until the beginning of 2015, Brazil yielded the world’s fourth largest pork production (3,47 million tons). Of these, 2,98 million tons were destined to the domestic market, while the remaining 493 thousand tons were exported, granting Brazil the 4th place in the world exportation ranking[27].

The total number of pigs slaughtered per year is around 1 billion, and nowadays, the largest swine production comes from Eastern Asia, especially China (by far the largest pork producer in the world - the country has over 500 million living pigs at any given moment)[28].

Consumption-wise, pork is the most consumed animal protein in the world, responsible for around 38% of the world meat production, and consumption varies geographically: its consumption is taboo in the Middle East, Israel and most of the Arab countries due to religious dietary restrictions established by the Jewish kosher and Islamic halal diets. Pork is, however, widely consumed in east and southeast Asia, all over Europe, Sub-Saharan Africa, the Americas and Oceania. According to the USDA - United States Agricultural Service[29], around 100 million tons of pork were consumed all over the world in 2006.

Following the separation of the commercially important cuts, abattoirs, slaughterhouses, butcher shops and supermarkets generate residue and waste,

also called by-products of animal origin: meaty flakes, natural casing, fat, cartilage, skin, bones, blood and entrails that can be turned into a wide variety of products, including food, animal feed, fertilizers and even fuel.

Image 33: Everything but the oink. Available at <animalsmart.org/feeding-the-world/products-from-animals>

In the book "Pig 05049"[30], the designer Christien Meindertsma meanders the intricate post-mortem trail of a common pig (the eponymous 'Pig 05049') and its parts. The book is composed of an extensive collection of photographs, assembled to document the impressive variety of products in which the different parts of a pig are used. It lists at least 185 non-swine products, ranging from firearms projectiles to artificial hearts.

The amount of uses for the parts and by-products of pigs is immense. However, it is important to accentuate that the definition of by-products (as well as the

consumption of pork) is rather dynamic, since it depends on regional and cultural habits, and on the evolution of technological processes itself. For some, what is nothing but waste can be considered an edible by-product or raw material for new products (EVANGELISTA, 2008. PARDI et al, 2007)[32].

Image 34. Book "Pig 05049". Available at: <<dublin.sciencegallery.com/edible/taste/pig-05049>

According to EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária, Pesca e Aquicultura. (TN: Port. "Brazilian Agricultural, Fishing and Aquiculture Research Corporation", a state-owned enterprise dedicated to the research and development of innovation and solutions for sustainable management of agriculture.) researcher Prof. Dr. Leandro Kanamaru, everything from the pig can be utilized in some way, opinion shared by the associate professor from the Department of Agroindustry, Food and Nutrition of the Superior School of Agriculture Luiz de Queiroz – ESALQ), Prof. Dr. Carmen Contreras Castillo. According to her, meat is a commodity, while the by-products have an ample variety of uses. From this point of view, it is possible to expand revenue through the complete commercialisation of an animal, not only its meat[33].

The commercial importance of by-products can also be seen in other countries, such as the United Kingdom where, according to Richard Lutwyche – a British pig farmer with over 60 years' experience, and member of the British Pig Association – big commercial farms send their pigs to large abattoirs. The abattoir will find different markets for all the by-products. Everything they can't sell they have to incinerate, so it's in their best interest to sell as much as they can."[34]

Brazilian slaughter companies produce over 52.950 tons in hairs, bristles, bones and glands, and their commercialisation yields over R$32 million (TN: around £6.71 million as of January, 2019) in revenue. The production of fresh, chilled or frozen offal and other pluck is around 37.134 tons, representing an income of about R$235 million (TN: about £47,5 million). The amount of skin and fresh, salted or dehydrated leather adds up to 6.799 tons, resulting in over R$8 million (TN: about £1,960 million) in revenue[35].

Despite all these by-products having the potential for being reused in some form as mentioned before, many times the market does not have the ability to completely absorb the production, as defended by Jamil Correia da Silva Jr., Master in Food Technology from the Federal University of Technology of Paraná (UFTPR), in his study about the reuse of by-products from the pork industry[36]. Besides, Jamil also affirms this portion not absorbed by the market generates serious problems related to waste and debris management, whose treatment incurs in higher expenses to industries.

One of the solutions for the waste problem is the recycling of animal residue, by processing the non-edible parts of the slaughtered animal, turning those into fats and flours. The Brazilian Animal Recycling Industry removes from the environment about 12 million tons in by-products per year, through recycling. These, if released

into the environment, would represent a major environmental and sanitary risk.[37] The absence of an animal residue recycling department in Brazil could render the whole industrial meat production unfeasible, since only in 2010, abattoirs, slaughterhouses and butcher shops generated 65kg of animal residue unfit for human consumption per inhabitant. This recycling results in resources for several industries, such as Hygiene and Self-Care, Petrochemical, flour for animal feed and others, as seen in the graph below (Img. 35):

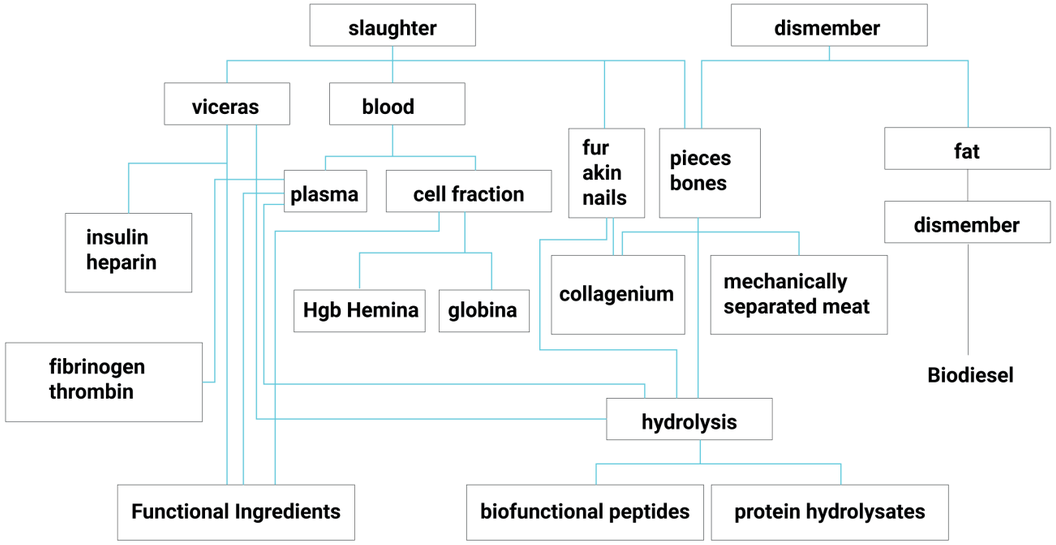


Image 35: Flow chart demonstrating the destination of by-products of pork production. Adapted from: <www.carne.3tres3.com.pt/os-peritos-opinam/aproveitamentos-dos-sub-produtos-suinos_150>

However, in spite of the vital importance of recycling, we may conclude that when any raw material with such a vast potential is recycled and is transformed in resources such as flour, glycerine among others, something of an underusage takes place, since the source has such a great economical potential, and a more rational use would be possible (TOLDRA et al, 2012).[38]

In order to do that, it is necessary to aggregate value to the by-products of pork production, through innovation that transforms a residue widely regarded as waste, into prime materials that – once subjected to processing – become desirable edibles, enticing to consumers (Ockerman & Basu, 2004a)[39], or non-edible products with economical profitability (such as plastics, pharmaceuticals, energy) (Ockerman & Basu, 2004b) [39].

7.5 Conclusion

The inquiry hereby presented can attest to the age-old adage that states: “From the pig, nothing ever goes to waste: everything but its oink”. Virtually every single part of the pig can be transformed into new products or resources. There is, however, an open question related to how to better put to use the potential of by-products and – more specifically in our work – of pigskin.

The present investigation shall unravel this question: how to aggregate value to pigskin? Even though there are known uses (food as pork scratchings, leather for several uses, collagen as resource for the cosmetics industry), I believe Pig It Yourself can become an alternative in aggregating value to this by-product, especially the smaller, non-consumable fragments, not large enough to be turned into leather products. It would be a better, less wasteful form of utilisation of the scraps, and a better exploitation of its untapped economical potential.

08.

A Receita

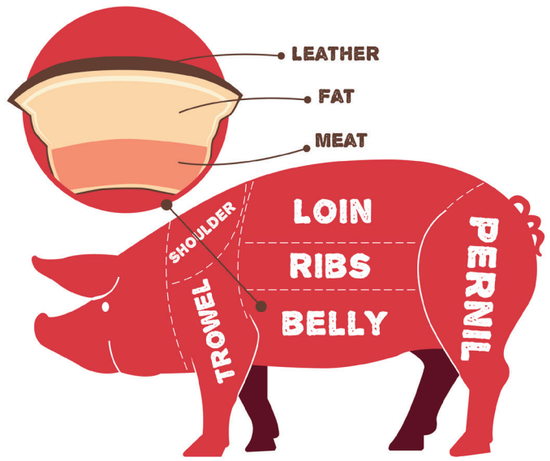


Image 36: Pork belly

Making PIY is actually a rather simple process for something this unusual. Of course, there are little secrets one can only learn by dealing with the material, but after a few attempts and tests, it was possible to reach a precise, efficient and consistent recipe, when compared to the previous ones.

Ingredients

500g pig skin

750ml water

Tools

Pressure cooker

Blender or mixer

Yields approximately 500ml PIY.

Image 37: Pig skin

Preparation

1. With a knife, remove all excess fat and/or meat still attached to the skin;
2. Fill the pressure cooker with water;
3. Place the skin in the pressure cooker and seal it;

(!) The water proportion must be 1,5ml for every gram of skin

4. Let it simmer for 40 minutes in medium heat;
5. Remove the skin from the pressure cooker and take the time to thoroughly clean the skin of any remaining fat;

Image 38: Liquid PIY

6. Place the skin in a blender or mixer and blend it. The result should be a homogenous paste.

It is important to blend the skin while it still warm (around 38°C). Below this temperature, it will congeal.

Storage

Image 39: PIY stored in glass container

The substance can be stored in fridge-safe containers, with smooth internal walls. I suggest mason jars, since it perfectly fulfils these requirements and can also be heated. The substance can be kept in the refrigerator for up to a month (further research on storage times is needed), without compromising its properties and usability.

If stored in the freezer, the water in the substance will freeze, making reheating for use difficult.

Reheating

During the process, several forms of reheating were tested, such as microwaving or directly in a saucepan. However, the most effective way was the double boiler method: bain-marie. This way, it is possible to keep the substance in its original container, and the method allows for better temperature control, and reduces the number of dirty containers during the process.

From 38°C, the substance will liquefy. Optimal temperature is 48°C. From this temperature upwards, it gets too viscous for proper manipulation.

Image 40: Bain-Marie reheating

Glycerination

In Bioplastic recipes, glycerol is used as a plasticizer, which softens the end product and adds in flexibility. For those reasons, glycerol was applied to the PIY recipe. In its natural state (i.e. without any additives), PIY is a material rather similar to Bakelite: non-translucent, rigid and unmalleable. By adding as little as 10% glycerol per PIY ml, flexibility increases as well as translucency. From 30% glycerol, the sample becomes as flexible as silicone.

GLYCEROL[40]

Glycerol (or glycerine) is an organic compound, from the alcohol family (that is, organic compounds bearing an OH group bound to a saturated carbon). According to the established by the IUPAC (International Union of Pure and Applied Chemistry) nomenclature of organic chemistry, the compound is called propane-1,2,3-triol.

PROPERTIES OF GLYCEROL:

Oily liquid in room temperature

Colourless

Odourless

Hygroscopic (absorbs air humidity)

Viscous

Sweet-tasting (TN: hence the “glyc-“ radical, from gr. Γλυκύς = “sweet”)

Fusion point: 17,8ºC

Boiling point: 290ºC

Polar in molecular geometry

Binds through Hydrogen bonds

Hydro and alcohol-soluble, little to no solubility in organic compounds; insoluble in hydrocarbons.

Bonding

As suggested by the tests, it is possible to bond the flexible and unmalleable materials (i.e., with and without glycerol). Both materials mix completely in their contact point, retaining their respective firmness.

At least one of the parts has to be in its liquid state (38º-50ºC) in order for the mixture to take place.

Drying, thickness and shrinking

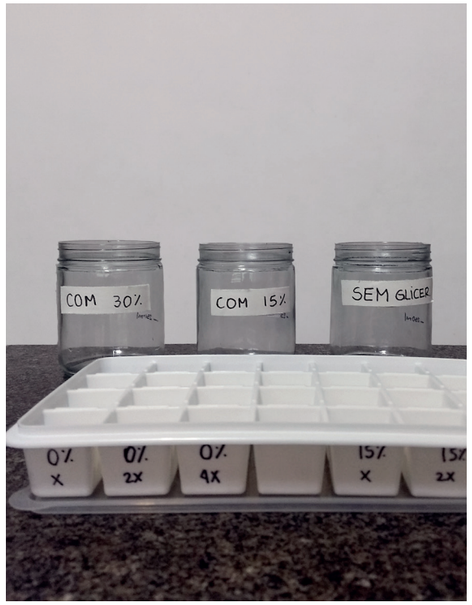


Image 41: Preparation for shrinking test

During the tinkering stage, I realised these three factors – drying, thickness and shrinking – were interconnected. I developed a test consisting in a series of repetitions varying in thickness and glycerination levels, to analyse how these three variables behaved.

The aim of the test was to determine what would be the percentage of shrinking in the samples, compared to their initial volume, in which way the amount of glycerol and the size of the sample would influence the shrinking rate, and if any distortion would take place.

In total, 36 samples were distributed as follows:

- 0% glycerol PIY samples in 5ml, 10ml and 20ml;
- 15% glycerol PIY samples in 5ml, 10ml and 20ml;
- 30% glycerol PIY samples in 5ml, 10ml and 20ml.

For each of the percentages of glycerol, four samples were drafted.

Image 42: Samples in cast.

	HEIGHT (CM)	WIDTH (CM)	DEPTH (CM)	VOLUME (CM)	SHRINKIN %
1X ORIGINAL	0,4	3,5	3,5	4,9	60
AVERAGE 0%	0,32	2,48	2,48	1,98	
0%	0,35	2,4	2,5		
	0,3	2,5	2,5		
	0,32	2,5	2,5		
	0,32	2,5	2,4		
AVERAGE 15%	0,31	2,73	2,73	2,28	53
15%	0,3	2,7	2,7		
	0,31	2,8	2,8		
	0,3	2,7	2,7		
	0,32	2,7	2,7		
AVERAGE 30%	0,38	2,8	2,78	2,91	41
30%	0,4	2,8	2,8		
	0,3	2,8	2,8		
	0,4	2,8	2,7		
	0,4	2,8	2,8		
2X ORIGINAL	0,8	3,5	3,5	9,8	61
AVERAGE 0%	0,63	2,48	2,48	3,83	
0%	0,7	2,5	2,4		
	0,6	2,5	2,5		
	0,6	2,5	2,5		
	0,6	2,4	2,5		
AVERAGE 15%	0,68	2,55	2,58	4,43	55
15%	0,7	2,5	2,5		
	0,7	2,6	2,6		
	0,7	2,6	2,6		
	0,6	2,5	2,6		
AVERAGE 30%	0,67	2,78	2,72	5,10	48
30%	0,8	2,8	2,8		
	0,6	2,8	2,7		
	0,7	2,8	2,7		
	0,6	2,7	2,7		

	HEIGHT (CM)	WIDTH (CM)	DEPTH (CM)	VOLUME (CM)	SHRINKIN %
4X ORIGINAL	1,60	3,50	3,50	19,60	53
AVERAGE 0%	1,33	2,63	2,63	9,13	
0%	1,40	2,60	2,60		
	1,30	2,60	2,60		
	1,30	2,60	2,60		
	1,30	2,70	2,70		
AVERAGE 15%	1,40	2,70	2,70	10,21	48
15%	1,40	2,70	2,70		
	1,40	2,70	2,70		
	1,40	2,70	2,70		
	1,40	2,70	2,70		
AVERAGE 30%	1,45	2,85	2,90	11,98	39
30%	1,40	2,90	2,90		
	1,40	2,80	2,90		
	1,50	2,90	2,90		
	1,50	2,80	2,90		

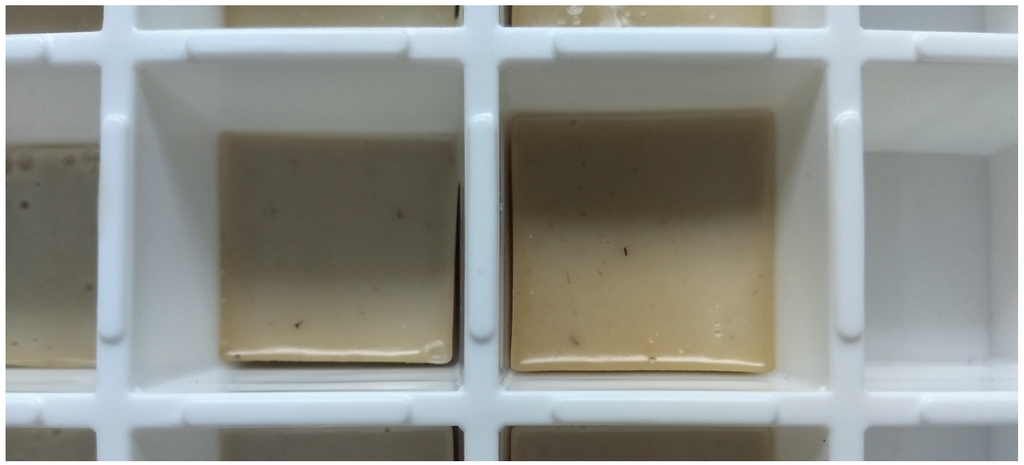


Image 43: Gradual contraction of samples

Percentage of shrinkage by thickness

	X	2X	4X
0% GLYCEROL	60	62	53
15% GLYCEROL	53	55	48
30% GLYCEROL	41	48	39

Results

It became evident that PIY has a drying pattern starting from the outer edges (the ones in contact with air), moving towards the interior of the sample; also, the larger the sample, the longer the drying time.

As mentioned previously, when the samples reach 38ºC, a change in texture occurs, gradually switching from viscous liquid to a more gelatinous state. At the beginning, it is still rather sticky, mas over time (according to measurements, around 30 minutes at 25ºC), it becomes more gelatinous, allowing for the comfortable manipulation, without concerns over stickiness. This is not, however, its final state, as its full drying takes, on average, one full day to complete. It should also be noted that drying times depend on average room temperature and air moisture.

Humidity is an important factor during drying: should the air be to humid during the first day of drying, the samples might mould before completely cured. The

preparation of a dry, well ventilated area for drying is essential to ensure the samples will dry before microorganisms start proliferating.

Beyond the shrinking shown in the tables, some samples also presented distortions. This effect had already been noted during the tinkering process. However, until the moment of writing, it was not possible to diagnose a cause. The 0% glycerol samples were the ones to present distortions, especially the thinner ones (10ml in volume presented the most distortion). Glycerination and thickness control are possible ways to avoid distortions.

The 20ml samples, initially 1,6cm thick, did not dry completely. This becomes evident by the difference in colour of the samples. This might have caused the smallest shrinking rate amongst all volumes. It was possible to determine the best PIY thickness to manipulate range from 0,1-1,0cm.

Image 44: Test results

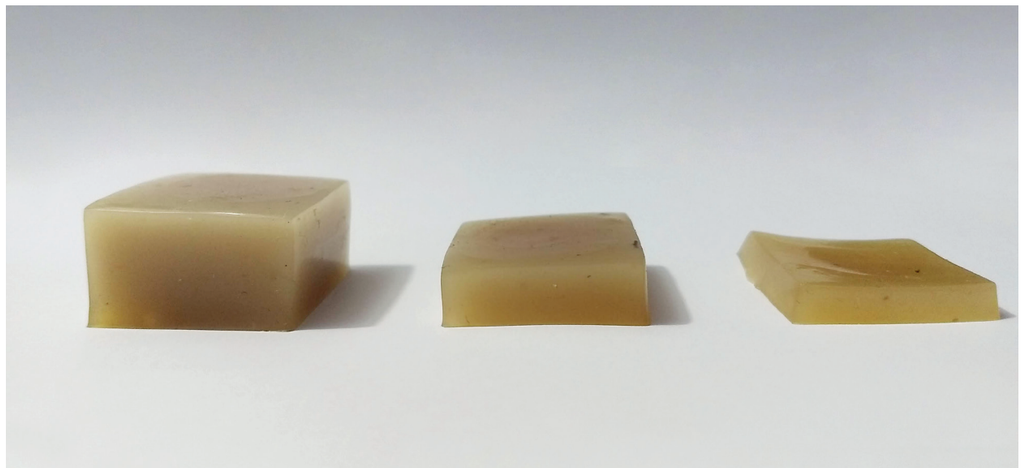


Image 45: Test results

09.

Coloration

The coloration of a material plays a fundamental role in the user perception about it. Therefore, this was one of the main aspects we tried to modify during the second stage of experimentation, once we achieved a stable recipe.

We tried some coloration methods during this stage, the first being natural ones, such as carrot peels and coffee grounds. Later on, we moved to acrylic paint (the only one at hand at the moment). Both methods worked correctly as concept proof this material can be altered in colour.

In this new research stage, I decided to continue exploring the coloration possibilities, especially the feasibility of employing organic pigmentation as done with carrot peels and coffee. Thus, the experiment was reproduced, utilizing beetroot peels, in order to attain a reddish hue.

The peels were placed in a saucepan with 100ml water, and simmered for some minutes. The mixture was filtered through a sieve to remove the peels, and

brought back to a simmer, for maximum concentration. After some time, 50g of PIY were added and blended in, resulting in a homogenous amalgamation. The resulting colour was a vivid magenta that lasted for approximately six days, when the mould started setting in once more.

The experiment was repeated using alcohol as solvent instead of water. I placed 19g of beetroot peels in a clean, sterilized glass container, added 150ml of 70% ethanol. The tincture was allowed to sit for four days, resulting in 100ml pigment.

In order to stabilize the pigment and avoid moulding, three types of natural antibacterial agents were tested: lemon juice, vinegar and potassium aluminium sulphate. Two samples (one containing glycerol, another one without it) were made, using the proportion of 30ml pigment: 7,5ml PIY, totalling six samples.

Image 46: Coloration test using beetroot peels

One week elapsed:

Image 47: Test results. Top row – glycerinated samples (from left to right): potassium aluminium sulphate, vinegar and lemon juice; Bottom row – samples without glycerol (left to right): potassium aluminium sulphate, vinegar and lemon juice

Two weeks elapsed:

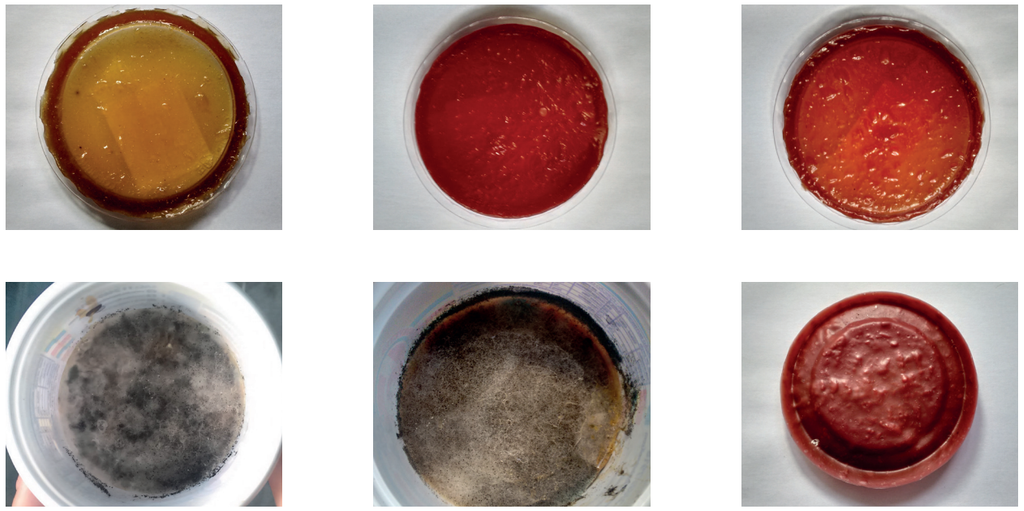


Image 48: Test results: Top row – glycerinated samples (from left to right): potassium aluminium sulphate, vinegar and lemon juice; Bottom row – samples without glycerol (left to right): potassium aluminium sulphate, vinegar and lemon juice

Glycerinated samples survived mould, but gradually lost their colour, the opposite of the observed in the samples without glycerol, which were completely overtaken by mould. From these results, it was possible to conclude that the utilization of natural colouring brings too many new factors into the development of a material that – by itself – already presents several challenging variables.

We decided then to explore food dyes, for we believed these could work well with organic matter such as PIY. Liposoluble food colouring was employed (the same ones used in chocolate).

In total, six samples were casted (three glycerinated ones, three without glycerol), in 2g dye for 100ml PIY proportions, in green, yellow and red.

Image 49: Preparation for the food colouring test

Image 50: Glycerinated samples in mold

Image 51: Samples without glycerol in mold

Results were stable: none of the samples presented any moulding, and the colours kept their brilliance, without any alteration. For this reason, this kind of pigmentation was chosen for further experimentation.

Image 52: Food dye colouring test results

10.

Conforming

Interactions along the tinkering process provided important insights on how to shape the PIY. Due to its drying, thickness and shrinking characteristics, finding the best methods for producing different shapes from the material has been a process of tests, failures and discoveries.

Since it is a liquid in its workable temperature, the easiest and almost intuitive way to shape the material, is to pour it in some sort of cast, and this is how we initially worked. Although easily done, there is a requirement for this shaping process to work: the cast. Several types of casts were tested, and the ideal would be to avoid hard casts such as metal, glass and porcelain entirely, since pieces tend to break apart or stick to the cast during removal. Flexible plastic casts are recommended, such as the ones used for chocolate.

This method, however efficient, is limited in shapes, since PIY yields its best results when in lower thickness, the produced shapes were almost bi-dimensional. We experimented in using positive and negative casts to attain different shapes; this method was counterproductive, for it made the drying process impossible.

Both these points – thickness and drying – are fundamental, and dealing with them during the conformation process is crucial to efficiently produce shapes from PIY, and it was while trying to balance these variables that I discovered another method.

Image 53: Conformation

During the research, the PIY was poured over an overturned plastic cup, to test for the possibility of producing shapes this way. This procedure yielded interesting results: the PIY was capable of reproducing the entire form of the cast and still dried efficiently, since almost the entirety of its surface is in direct contact with air.

OAnother variable arose from this process, however: shrinking. Since PIY shrinks during drying, the piece tends to stick even more to the cast, making its removal rather difficult, and almost impossible to do without damage. As a way to solve this issue, glycerol was applied to the surface of the cast, as a sort of lubricant to ease cast removal.

Other issue stemming from this type of casting is the mold itself: it is hard to find molds in the desired shape. Looking for a solution, I started producing my own molds in Plasticine, which yielded great results, since it enlarges the range of possible shapes, allows for the easy cast removal even in complex shapes without any damage to the piece, and the material can be reused to create other casts. This conformation method proved to be amazingly effective, is was chosen to be used for the remainder of the research.

Despite the long research process and the production of tens of samples, I believe it is still possible to find other different methods to conform PIY, and deem it an important topic for future research. However, due to the scope and time limits of the project, I decided not to investigate any further, since the presented solution was considered satisfactory for the time being.

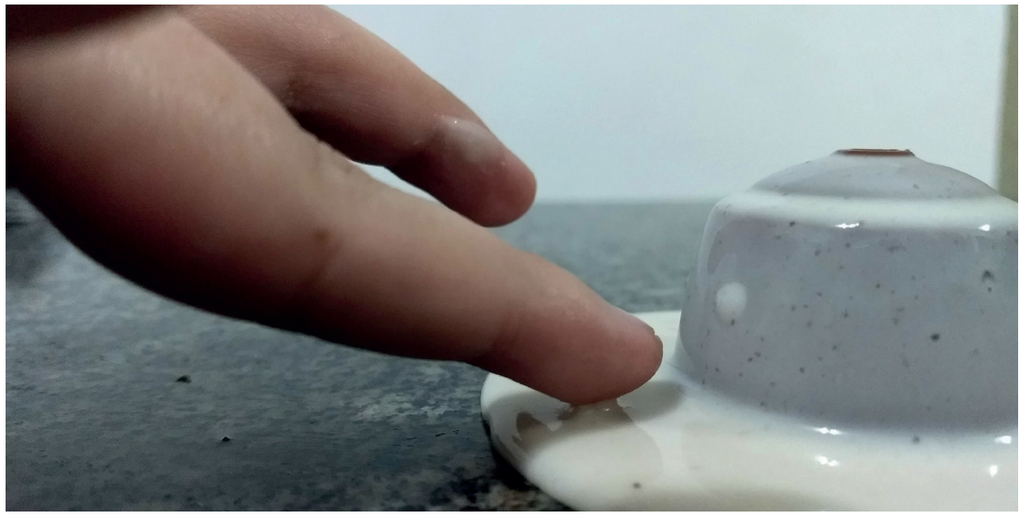


Image 54: Conformation – PIY is sticky to the touch before completely dry

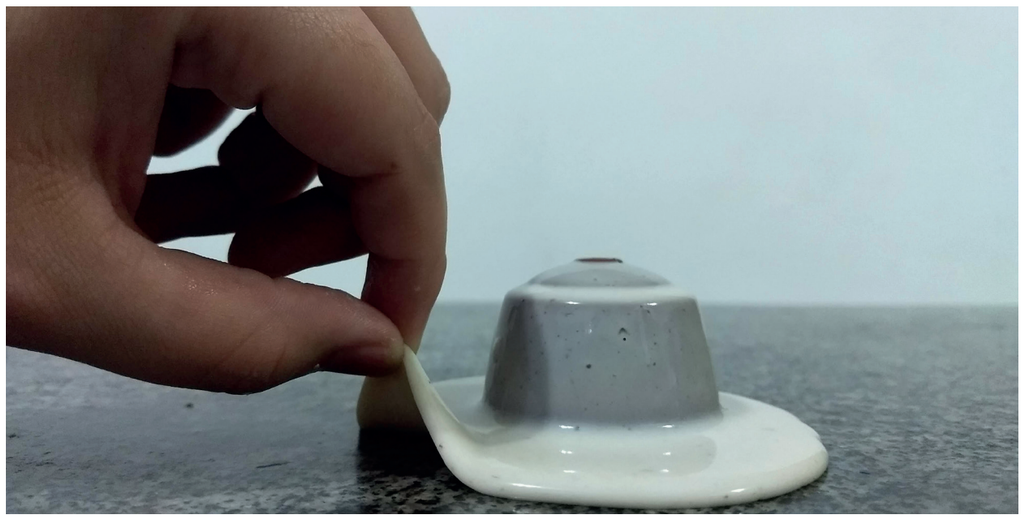


Image 55: Conformation – PIY already apt for handling, but still not completely dry

11.

Decomposition

Everyday our ecosystems are invaded by residue of human action, and – in most of the cases – these are made from materials impossible for nature to absorb. In this scenario, it is essential that researchers of new materials keep in mind its potential recyclability, biodegradability & compostability.

PIY is composed in its entirety of organic matter, and as such, it was fairly probably biodegradable. This intuition proved to be true during the exploratory stage. However stable after drying, some samples presented small specks of moulding before the they could dry completely. This was the second forewarning of the possibility the material could be decomposed by microorganisms.

Further investigating these questions, I conducted an experiment consisting of burying two samples (one glycerinated, one without glycerol) into the same plant

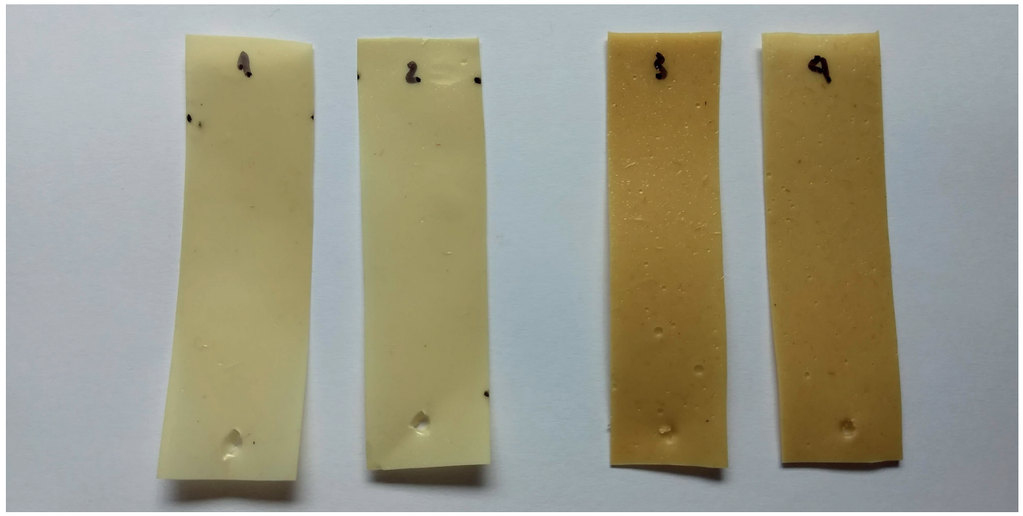


Image 56: Samples prepared for testing. 1 and 2, without glycerol; 3 and 4 glycerinated

pot. As control group, two samples (one glycerinated, one without glycerol) were kept exposed to the elements. The experiment took one month to be concluded, and both buried samples were completely consumed by microorganisms and did not affect the plant. The control group samples remained unaltered.

The data gathered in experiments and their subsequent analysis proved the biodegradability of the material, which only confirmed our assumptions.

Another factor arose during the recycling research: by subjecting completely dry samples of the material to heat, we noticed they turned back into liquid, and could be cast again. This discovery shows the material has the potential for recycling and reusing, by using the same samples reheating process, as shown in chapter 8.

Image 57: Samples 1 and 3 being buried in a plant pot

Image 58: Samples 2 and 4 exposed to the elements

Other discovery made during this process is that PIY is extremely hydrophilic, that is, it easily absorbs water. After placing it for a few days inside a container filled with water, the material changed it physical state, from solid to practically liquid, partly mixing itself into the water.

Image 59: From samples 1 and 3, only their retaining strings remained

RECYCLING

Recycling is the process of converting residue into materials or products of potential usefulness. This process ensures the reduced consumption of raw materials, energy utilization, and water and air pollution; it also reduces the need for conventional rubbish treatment, and the amount of greenhouse effect gases emitted. Composting or reusing of biodegradable refuse is also considered recycling.

12.

Mechanic Tests

Thanks to the Department of Chemical Engineering of the University of São Paulo, alongside with the PhD in Chemistry student Bianca Chieregato Maniglia, we were able to conduct mechanical tests on the material.

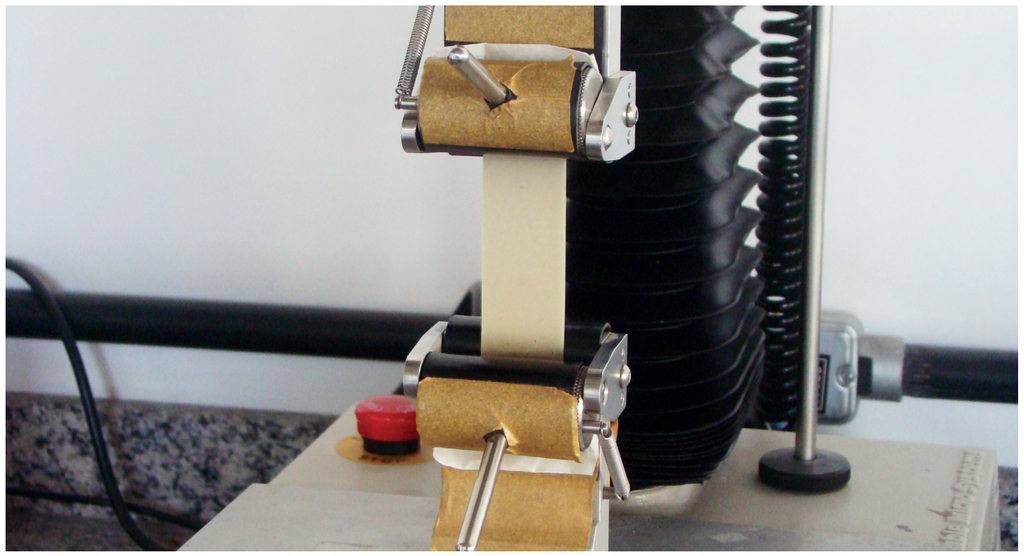


Image 60: Texture analyser, probe A/TGT (Stable Micro Systems)

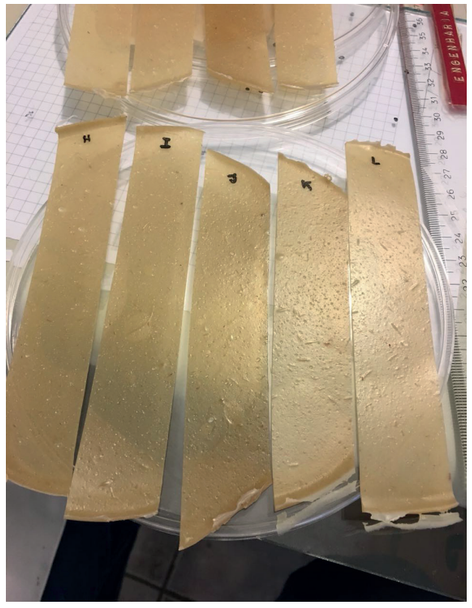


Image 61: Samples preparation

For the mechanical tests, the texture analyser TA TX Plus (TA Instruments, England) was employed. The data gathered was analysed through the Texture Exponent software (version 4.0.13.0), according to the ASTM Standard method D882-12 (ASTM, 2012)[41]. The proof-bodies, measuring 10cm in length and 2,7cm in width, were previously stored in humidity-controlled environment (75%) for two days. The uniaxial traction test was conducted at the traction speed of 50 mm/min. The tension at rupture (RT, in MPa) and the deformation at rupture (RD, in %) were directly obtained from the tensile curve vs deformation. The elastic modulus (E, in MPa) was determined through the calculation of the angular coefficient of the linear section of the tensile curve vs elongation. The initial adherence distance and the test velocity were 10 mm and 0,9mm/s-1, respectively.

SAMPLE	THICKNESS (mm)	TENSION (MPa)	ELONGATION (%)	MY (MPa)
NO GLYCEROL	0,84±0,20	4,52 ± 1,94	267,66 ± 83,81	5,00 ± 35,36
GLYCERINATED	0,94±0,28	2,79 ± 0,12	996,36 ± 2,92	7,50 ± 3,54

13.

Sensorial Tests

One of the sensorial evaluation methods presented during the Design Material Experiences course was the questionnaire titled “Experimental Evaluation”, which consisted in quantitative and qualitative evaluations of characteristics of the material, the sensations it causes and emotions it evokes, based on Elvin Karana’s 2009 *Sensorial Evaluation Scale*[42]. The main goal of the test is to evaluate how the material is perceived by users through its exploration and handling.

The test was conducted at the university, with eight first year students from the Design course, being four males and four females. At the beginning of the test, we explained the questionnaire and what aspects would be evaluated. We did not reveal the composition of PIY (we only mentioned it was made from animal matter), so as to avoid preconceived images about the material.

In total, 14 samples were evaluated, all specifically selected for testing and characteristics comparison. For the evaluation of results, the answers were grouped in 4 questionnaires: pure samples, coloured pure samples, glycerinated samples, and coloured glycerinated samples.

Image 62: Users during test application

Image 63: Samples used in test

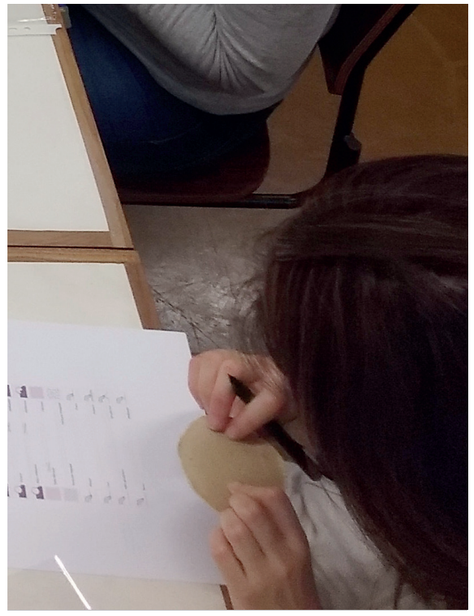


Image 64: User manipulating sample

Pure Samples

Pure

Pure – Small Container

Pure – Strip

	3	2	1	0	1	2	3	
Subtle color			■					Vivid color
Cold color				■				Warm color
Opaque	■							Transparent
Matte					■			Glossy
Not reflective					■			Reflective
Not Fibrous								Fibrous
Regular texture								Irregular texture
Soft								Hard
Smooth	■							Rough

	3	2	1	0	1	2	3	
Unsticky		■						Sticky
Dry					■			Wet
Cold				■				Warm
Unflexible								Flexible
Rigid								Elastic
Fragile						■		Resistant
Lightweight	■							Heavy
Odorless								Smelly
Disgusting smell				■				Pleasant smell
Silent						■		Loud
Deep sound								Acute sound

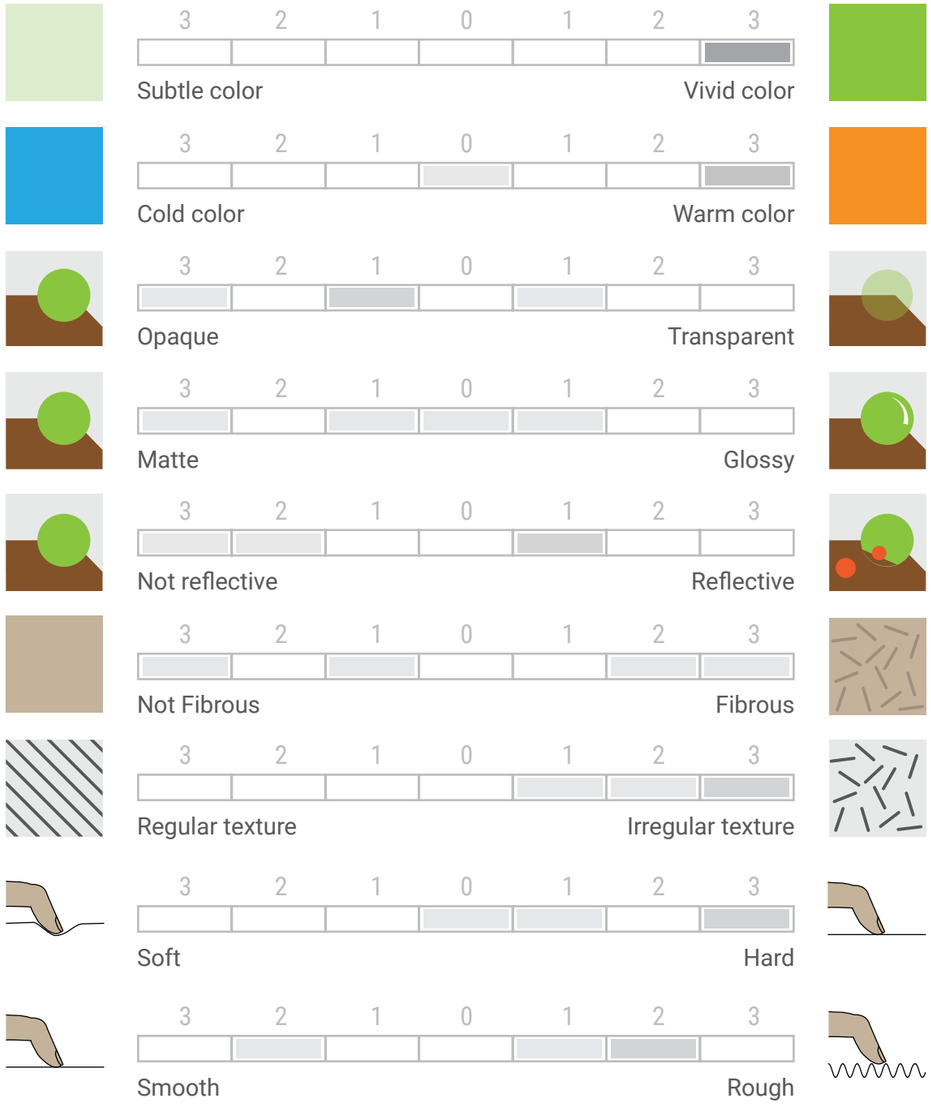
Pure Coloured Samples

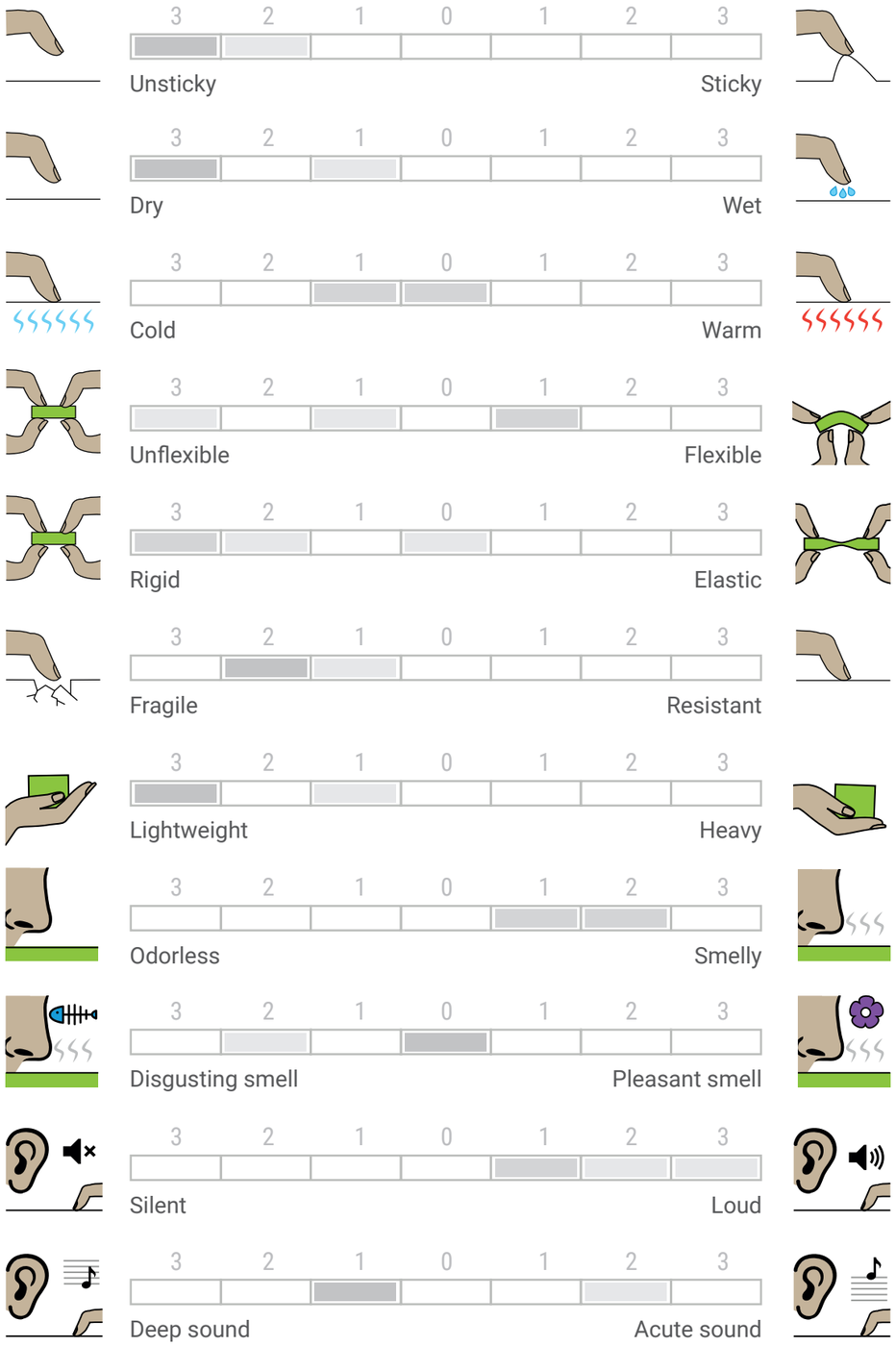
Pure Red

Pure Red – Bowl

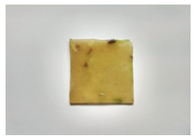
Pure Red – Small Container

Pure Light Red

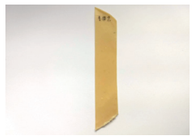




Glycerinated Samples



Glycerinated – Scented



Glycerinated – Strip

Glycerinated – Scented

Glycerinated

3 2 1 0 1 2 3

Subtle color — Vivid color

3 2 1 0 1 2 3

Cold color — Warm color

3 2 1 0 1 2 3

Opaque — Transparent

3 2 1 0 1 2 3

Matte — Glossy

3 2 1 0 1 2 3

Not reflective — Reflective

3 2 1 0 1 2 3

Not Fibrous — Fibrous

3 2 1 0 1 2 3

Regular texture — Irregular texture

3 2 1 0 1 2 3

Soft — Hard

3 2 1 0 1 2 3

Smooth — Rough

3 2 1 0 1 2 3

Unsticky — Sticky

3 2 1 0 1 2 3

Dry — Wet

3 2 1 0 1 2 3

Cold — Warm

3 2 1 0 1 2 3

Unflexible — Flexible

3 2 1 0 1 2 3

Rigid — Elastic

3 2 1 0 1 2 3

Fragile — Resistant

3 2 1 0 1 2 3

Lightweight — Heavy

3 2 1 0 1 2 3

Odorless — Smelly

3 2 1 0 1 2 3

Disgusting smell — Pleasant smell

3 2 1 0 1 2 3

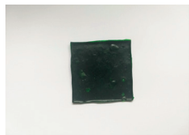
Silent — Loud

3 2 1 0 1 2 3

Deep sound — Acute sound

Coloured Glycerinated Samples

Glycerinated – Green



Glycerinated – Scented Green

Glycerinated – Red

3 2 1 0 1 2 3
Subtle color — Vivid color

3 2 1 0 1 2 3
Cold color — Warm color

3 2 1 0 1 2 3
Opaque — Transparent

3 2 1 0 1 2 3
Matte — Glossy

3 2 1 0 1 2 3
Not reflective — Reflective

3 2 1 0 1 2 3
Not Fibrous — Fibrous

3 2 1 0 1 2 3
Regular texture — Irregular texture

3 2 1 0 1 2 3
Soft — Hard

3 2 1 0 1 2 3
Smooth — Rough

3 2 1 0 1 2 3
Unsticky — Sticky

3 2 1 0 1 2 3
Dry — Wet

3 2 1 0 1 2 3
Cold — Warm

3 2 1 0 1 2 3
Unflexible — Flexible

3 2 1 0 1 2 3
Rigid — Elastic

3 2 1 0 1 2 3
Fragile — Resistant

3 2 1 0 1 2 3
Lightweight — Heavy

3 2 1 0 1 2 3
Odorless — Smelly

3 2 1 0 1 2 3
Disgusting smell — Pleasant smell

3 2 1 0 1 2 3
Silent — Loud

3 2 1 0 1 2 3
Deep sound — Acute sound

Relevant Points

- **Odour:** Most of the responses mention the odour of the material, stating it is peculiar and persistent (it lingers on the hands).
- **Absence of Colour:** Test responses about pure samples show the absence of colour induces comparisons with “raw” materials, such as gelatine, skin, sunflower seed oil, and wax.
- **Colour:** Coloration induces the user to correlate the material with materials such as fruit, blood, organs, Plasticine. Besides, colours evoked positive emotions: some users mentioned the sample was “beautiful”, “agreeable” and other adjectives that did not arise when dealing with the uncoloured samples.
- **Texture:** Most of the samples show two textures – one smooth (on the surface that used to be in contact with the mold), one coarse (on the surface exposed to the air). Also, on non-glycerinated samples, the colouring causes a texturization; this stems from small undissolved pigment specks. Due to those differences in texture amongst samples, responses varied. It is possible, however, to identify an emerging pattern: the smoother texture tends to elicit comparisons with synthetic materials, such as plastic, silicone and resin, whereas the rougher texture was compared to natural products, such as fruits, paper, dried fruits, and tomato sauce.
- **Emotions and Feelings:** Familiarity, nostalgia, intriguing, strangeness, repulsion, anguish, curiosity, ambiguity, disgust.
- **Adjectives:** beautiful, pleasant, natural, rustic, cheap, resistant, high quality, irregular, soft, curious, fun, flashy, different, uncomfortable, non-resistant, fragile, amateur, waste, low quality, handmade, light, rigid, weird, fibrous, ecologic, comfortable, disgusting.

Image 79: Samples used in test

14.

Material Profile

From the first edition of the Designing Material Experiences course, the faculty projected a model of profile, to make the communication of materials easier for students. Students were expected to populate the model with text and images, providing a name for the material, its description, properties, sensorial characteristics, ingredients, production process and a slogan to provide a narrative of their materials.

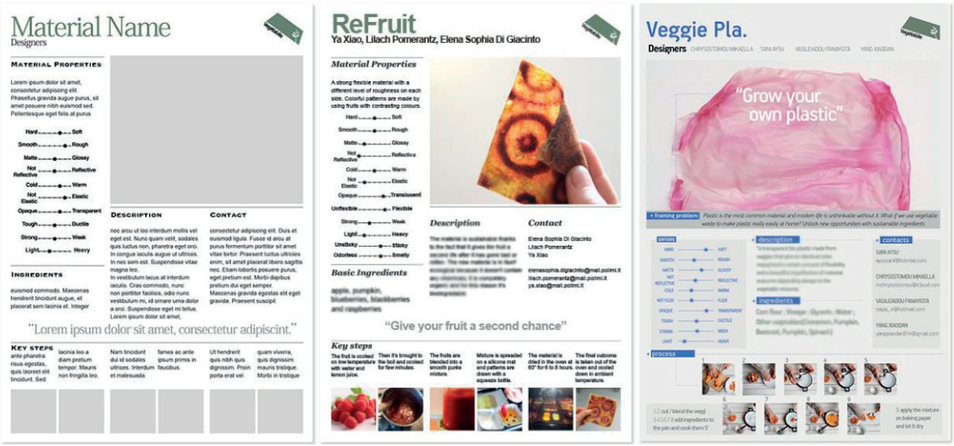
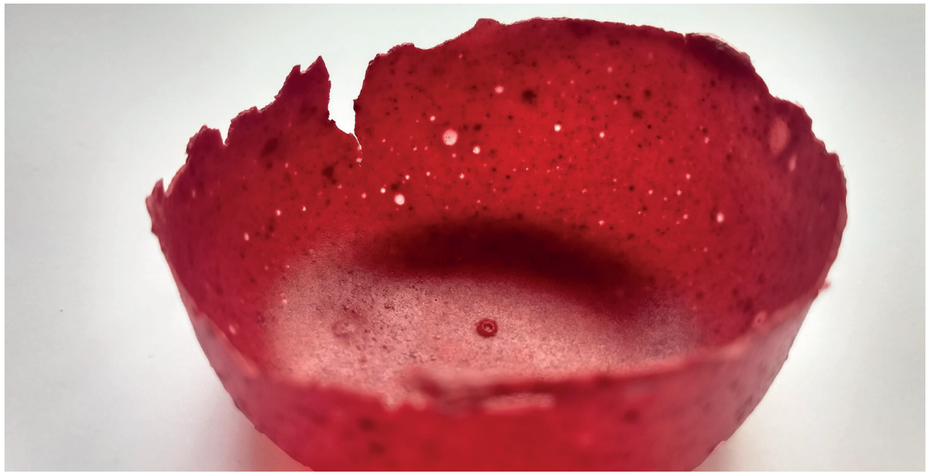


Image 80: Examples of material profile

Profile – Pure PIY



+ properties

Hard	Soft
Smooth	Coarse
Matte	Glossy
Non-Reflexive	Reflexive
Cold	Warm
Rigid	Elastic
Opaque	Translucent
Resistant	Fragile
Light	Heavy

+ description

This is a semi-translucid material, made from pigskin, it alters the properties of pigskin, becoming hard and unmalleable.

+ ingredients

Pigskin

Water

+ process

1

2

3

4

Profile – Glycerinated PIY

+ properties

+ description

This is a semi-translucid material, made from pigskin and glycerol, which altered the properties of pigskin, becoming elastic and translucid.

+ ingredients

Pigskin
Water
Glycerol

+ process

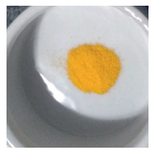
1

2

3

4

5



Summary of the Material

TECHNICAL CHARACTERISTICS

• What are the material's technical characteristics?

High resistance to traction, varying hardness degrees, opacity levels and malleability.

• What are the material's limitations and opportunities?

Limitations: hydrophilic, low resistance to heat, and the origins of the raw material.

Opportunities: Ease of preparation, malleability and degradability.

• What are the most appropriate production technologies for shaping the material?

Casting.

• Regarding other manufacturing processes, how does the material behave when subjected to conformation methods different from the previously employed?

Some tests simulating extrusion were conducted, and the material showed great potential for conformation through this method. Further research is needed.

EXPERIENCE CHARACTERISTICS

• What are the unique sensory qualities of the material?

The most outstanding sensorial characteristics come from the raw material, the pork skin makes the material have a very specific texture and odor.

• What are the material's most and least pleasing sensorial qualities (according to users)?

Least pleasing: lingering odour and greasiness on hands after manipulation.

Most pleasing: flexibility and texture.

• Is the material associated to any other material due to aesthetic similarity?

Uncoloured samples are more frequently associated with "raw" materials such as gelatine, skin, sunflower seed oil and wax. Coloured samples are associated with plastic, fruits, blood, organs and Plasticine.

• How do people describe the material? What kind of meanings does it evoke?

It has been described as beautiful, pleasant, natural, rustic, cheap, irregular, soft, curious, fun, flashy, different, uncomfortable, handmade, light, rigid, weird, fibrous, ecologic, gelatinous, rubbery, warm, durable, flexible and disgusting.

• Does the material evoke any particular emotions?

There is great ambiguity in users' responses, which shows that interactions always elicit an intense reaction – be it repulsion and disgust or curiosity.

• How do people interact and behave with the material?

The material causes an initial curiosity which induces users to want to pick it up, followed by the strangeness caused by the difference in texture (if the samples are glycerinated or not); users keep squeezing the samples, due to its softness and flexibility. Also, users usually smell the material, due to its peculiar odour.

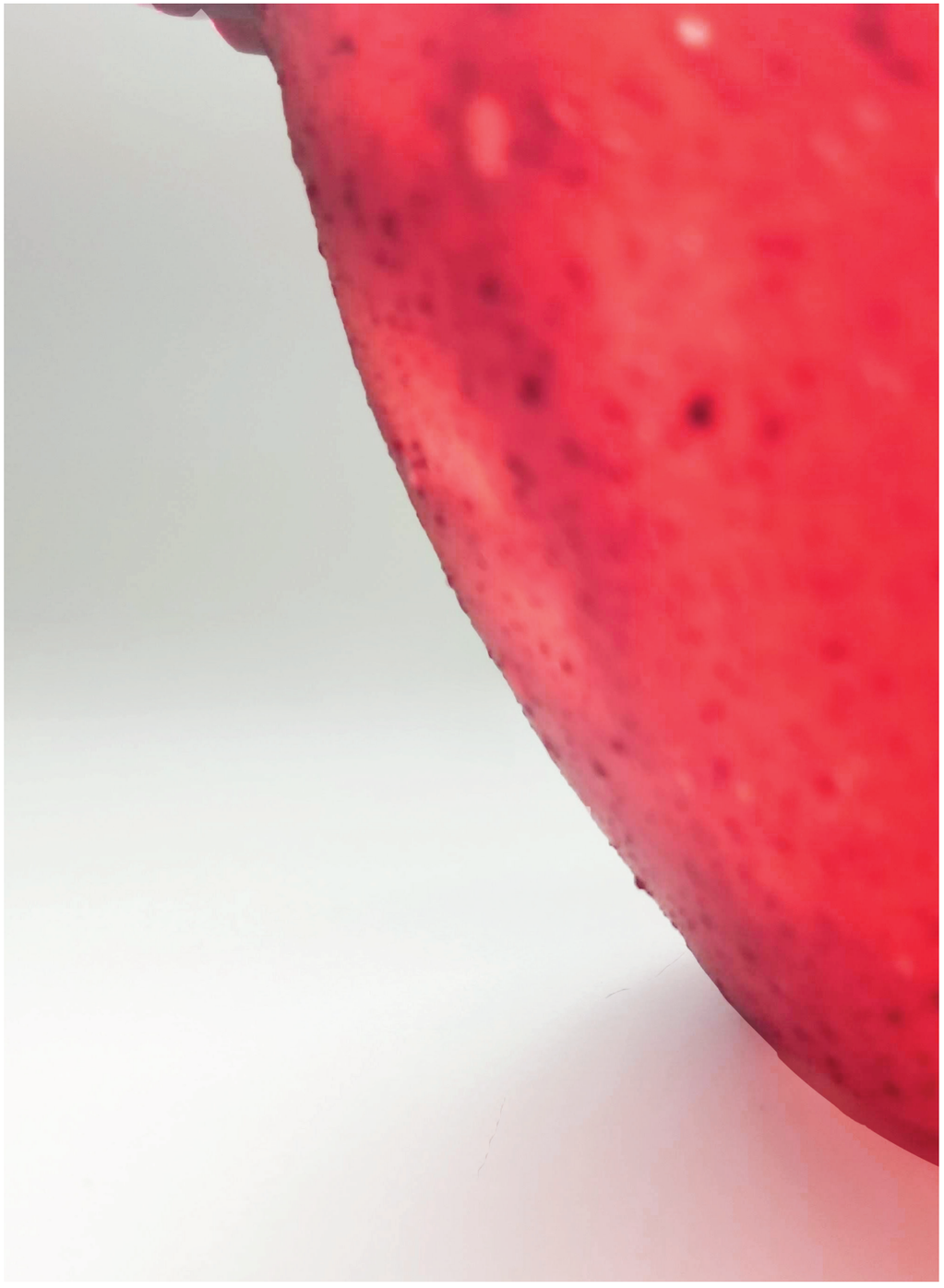


Image 92: Close-up of a sample

15.

Material Benchmark

Benchmarking is a very important tool for the development of the project, since it aids in determining the most adequate application of a new material. During the process, it is possible to widen the vision about uses and experiences and discovering new possibilities for the material.

The basic principle is to position the material amongst other similar and/or alternative ones, in order to obtain insights about possible application areas, emerging material experiences and other topics related to the design field (Karana et al, 2015)[43]. For that, the research area was divided in materials belonging to three groups:

- Material from the same raw material: Pig leather
- Material of similar technical characteristics: Biopolymer
- Materials with the same development process: Animal DIY materials

In each case, the sensory and technical characteristics were analysed, besides their environmental impacts.

Couro de porco

Image 93: Pig leather. Available at <goo.gl/grqbgM>

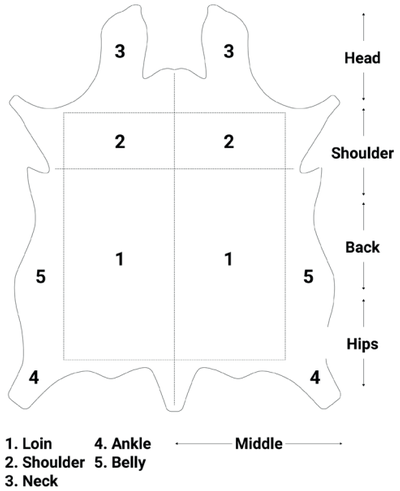


Image 94: Pig leather cuts. Adapted from <goo.gl/htBd8>

Description: It is an easily identified material, since its hair follicles are well developed and for resembling the human skin. It is a fine, soft and thinner than most leathers, which increases its value and amplifies its usage in clothing[44].

Process: Obtained by treatment of pig skin, by using the layers known as grain and split[45].

Technical characteristics: Resistant, malleable, flexible, resists moisture without hardening, excellent abrasion resistance, great durability[46].

Environmental impact: After the animal is slaughtered its skin is removed and sent to tanneries, where the raw leather is soaked in chemicals and processed for use in industries. During the tanning process, waste is produced and some of the by-products are toxic, such as chromium and colouring. These residues affect negatively local ecosystems, causing great environmental impact.

In order to reduce environmental impact, several measures have been established in some tanneries, aiming to minimize the environmental effects stemming from the process, such as chromium recycling, substitution of toxic dyes for other, less pollutant alternatives, recovering or substitution of chemical resources, amongst others. It is still, however, a very pollutant process. [47]

Bioplastics

Image 95: Bioplastics. Available at <goo.gl/4zRzMT>

Description: The properties of bioplastic are similar to those of a common plastic, allowing for its utilisation in packaging and disposables, amongst many other applications.

Process: While synthetic plastics are obtained through fossil carbon processing from petroleum, bioplastics/biopolymers use carbon from renewable sources, such as cassava, rice and corn starches[48].

Technical Characteristics: According to Ramalho (2009)[49], biodegradable plastics have physical and chemical properties similar to those of common plastic, but take anywhere from 18 to 20 months to decompose. That is because many microorganism – such as bacteria and fungi – found in soil secrete enzymes capable of breaking down biodegradable plastics, which is impossible when dealing with conventional plastic.

Environmental Impact: Most bioplastics/biopolymers currently produced worldwide are composed from renewable sources and certified compostable. These materials do not need fossil carbon as base of its manufacturing process. In fact, the process uses the carbon captured by plants from the atmosphere during their growth. When bioplastic (biodegradable) packaging is incinerated or composted, the renewable (or biogenic) carbon collected by plants during their primary growth is returned to the atmosphere. Therefore, carbon re-enters its cycle. Some bioplastics industries, however, also use fossil fuels as energy for the different stages of production. These factors render the global evaluation of environmental impact of bioplastics (in comparison with other types of packaging) a rather complex subject[50].

Animal DIY Material - Hidden Beauty[51]

Image 96: Animal DIY Material – Hidden Beauty. Available at <www.guterdort.de/?page_id=42>

Description: This project questions if it is possible or not to leave behind aesthetic stereotypes and appreciate beauty for its appearance: how can we change our habitual perception? Based in experimental materials researches, inner skins from sheep, pigs and cows, and animal entrails such as bladders and intestines – usually considered disagreeable and promptly discarded as waste – are now used to create unique, beautiful objects. If skins are considered for what they are, their unprecedented shape and the unusual leather surface reveal their occult value. An elaborate process of vegetable tanning transforms the material into leather, which in turn serves as raw material for diverse objects that need not to conceal their origins.

Process: Initially, the entrails are completely cleaned of fat layers and blood. These are then acidified by constant agitation in a diluted formic acid solution.

Once the inner skins reach the intended pH, they are tied and hung submerged in vegetal liqueur for the tanning process. This liqueur is made from the dissolved tannin present in the bark of the Queensland silver wattle (Acacia podalyriifolia), and Quebracho trees (TN: Genus Schinopsis, native from Argentina, Paraguay, Peru, Brazil and Bolivia).

Once the desired coloration is reached, the skins are washed and lubricated with three different fats in a tannin barrel. Through lubrication, leathers are rendered soft and flexible. Afterwards, the entrails must be acidified once more, in order to fixate the fats. The drying plays an important role in the manufacturing process. The longer the leather is crushed, the softer and more flexible it turns. To preserve the original shape of the entrails, the individual pieces are manually crushed and pulled until dry.

Technical Characteristics: The use of inner skins has always been common and widespread up until the XX century. Once clean, these dry easily and become a material whose texture closely resemble that of paper. This material is rather stable and impermeable, suitable for manufacturing light and elastic containers for the transportation of liquids, cheese, tobacco or documents.

Environmental Impact: This project has little to no negative environmental impact, since it aims to utilize an animal by-product usually considered as residue. Besides, the skin treatment is made with formic acid, a naturally-occurring product of biotransformation through metabolic reactions within living organisms. It is highly biodegradable, both in water and in soil. It is only considered harmful to water organisms, such as fish and plankton, for it may cause an imbalance in water pH (HSDB, 2006)[52].

Conclusion

Each material analysed contributed importantly to the research: the leather allowed us to better understand the characteristics of our primal matter when processed differently, and how leather tanning can be toxic and greatly impact nature. In the case of bioplastics, it was possible to understand that, even though both present analogous aesthetic characteristics, PIY bears rather different technical characteristics in comparison to the biopolymer, which might discourage the idea of introducing it as a competitor to the bioplastics. Interesting, however, was the case of Hidden Beauty, which allowed me to rethink the aesthetics of my material, and how the use of its visceral characteristics to design a unique experience can be one of its most appealing aspects.

16.

Envisioning

As presented in chapter 5, in the envisioning stage the designer must formulate their intent through design, i.e. the final object of the process. It was possible, therefore, to use this stage to analyse all the discoveries and results from the research and surveys conducted throughout the project, in order to create context and propose applications.

16.1 Result Analysis

Since the beginnings of this project, the comparison of PIY with plastic has been inevitable, since the first characteristic to be noted is the aesthetic similarity between PIY and this ubiquitous material we are so used to see. Similarities end at that point, however, since technical characteristics of both materials are wildly different.

PIY has relevant technical limitations when compared to conventional plastic, such as low fusion point and hydrophilia. These ended up inducing the dismissal of the idea of proposing PIY as a substitute for (bio)plastic, at least for the time being. On the other hand, when we focus away from plastic, it is possible to analyse the new material for what it is, without the need to fit in predetermined parameters, which allowed the analysis of its characteristics under a new light.

Scrutinizing the technical characteristics of the material, now freed from comparisons, we were able to notice some interesting points::

- **Low fusion point:** what was deemed as a negative trait in comparison to plastic, now becomes a strength, since this characteristic favours the production, casting and recycling of the material;
- **Raw materials:** the ease of access to its primal matter makes production easier;
- **Reusability:** as mentioned in the first point, its low fusion point allows for the recycling of the material, even after completely dry;
- **Hardness/Elasticity:** the reaction of PIY with glycerol allows the exploration of countless levels of hardness and elasticity;
- **Surface finish:** PIY is able to reproduce fairly well the details on the surface of its cast, which ensures the ability to modify its surface finish;
- **Coloration:** The material accepts pigmentation rather well, and it can be produced in vivid and bright colours;
- **Odour:** Despite its strong odour, PIY allows for the addition of fragrance, which facilitates the creation of different experiences;
- **Aesthetics:** The texture of the surface that dries in contact with air, the shrinking and the distortion of the material are all characteristics that proved to be almost incontrollable during the process. At the same time, however, what is deemed as imperfections, also render each piece unique.

Regarding the sensorial characteristics, test results showed that user interactions with PIY is highly reactive and elicits contradictory emotions, shocks and surprises. The smell, the texture, the greasiness – undeniable characteristics of the material – are present in each sample, and at the root of the emotions and relationships built with the user, however good or bad.

This experience, even though strong, can be very positive, since it renders the material intriguing and curious. These adjectives, amongst others such as 'flashy' and 'weird' arose as striking, and can be use in future applications, since those were the ones I ascribed to the material, and that motivated me to continue to research the PIY.

16.2 Continuing the process

The ideation process was non-linear: some of the ideas of possible applications appeared throughout the research (Image 97) and many more certainly exist beyond my knowledge as a designer. However, those still appeared to be detached from the project, which encouraged me to keep seeking for applications.

Highlighting the technical and sensorial qualities of PIY greatly assisted in this process, as it clarified (through the perceived strengths and weaknesses of the material) which could be their roles within a certain application, and in the creation of unique experiences. Continuing the method, I decided to materialize these results in an application scenario. This process was guided by questions the MDD method poses (page 40). Through the answers to those questions I determined the scenario needed to follow these criteria:valorizar a matéria-prima;

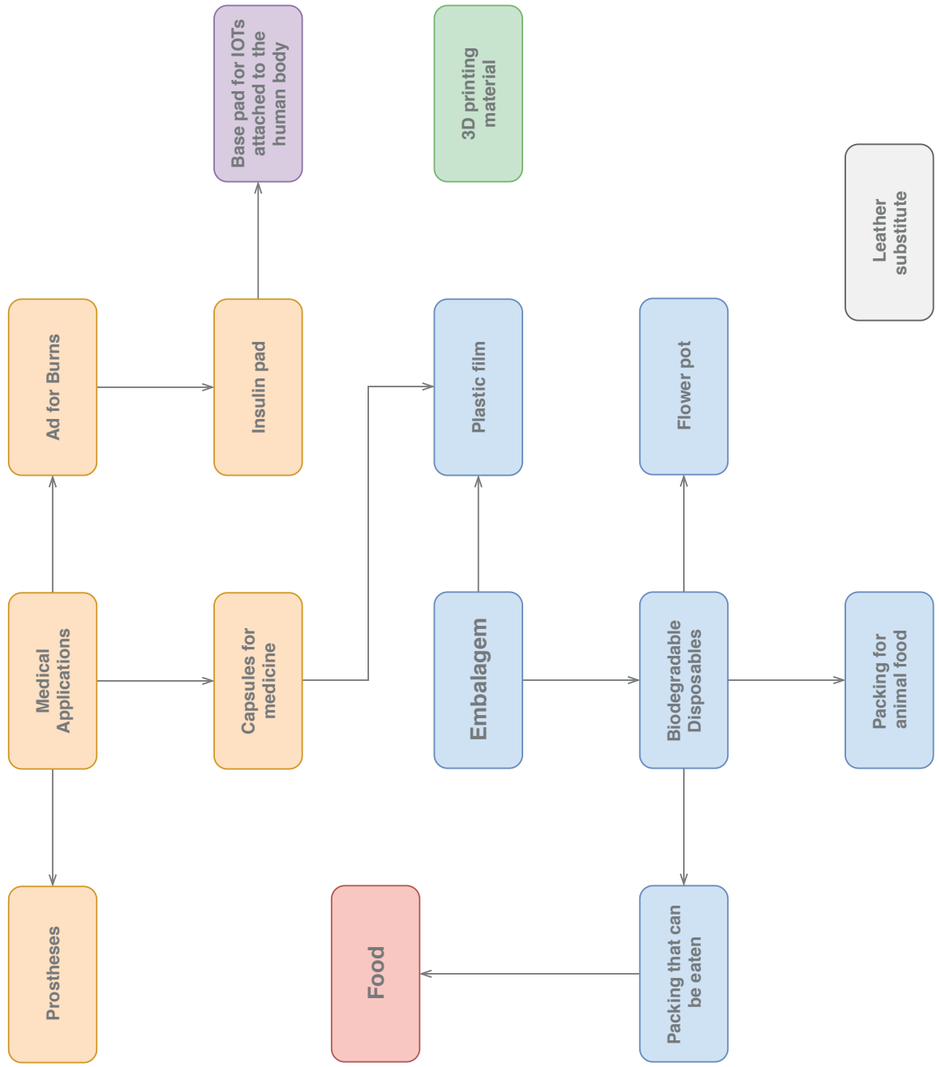


Image 97. Brainstorming for possible applications

- That the application valorises the raw material;
- That the material is used in a sustainable;
- That the application brings about the sensation of discovery, surprise, familiarity (all of which appeared during the sensorial test);
- That the technical characteristics are taken into account for the proposed application.

16.3 Problem

Reflecting upon the scenario criteria and the material's characteristics, I was reminded of a problem I ran into during the tinkering process: where to begin? As mentioned previously, the idea of creating a new material might seem complicated, especially for those used to a more classical approach of project development, and this posed a challenge for me as well. As shown in previous chapters, the project development took an organic pathway, alongside the discoveries of each of the stages. When the project started, we had no preconceived idea of a destination; we even questioned if there was a destination to be reached at all.

Experimental processes such as this one gives us complete freedom to create. This can be good, but also terrifying, rendering the beginning a complex stage. A solution to this (also previously mentioned, and a rather common one within the DIY universe) is the abundance of information available. There are several databases, as seen in previous chapters, that make the beginning a little easier, and if those are not enough, there are recipe books, such as "Recipes for Material Activism" and "Material Alchemy".

Image 98: Book "Material Alchemy". Available at < www.bispublishers.com/materialalchemy.html>

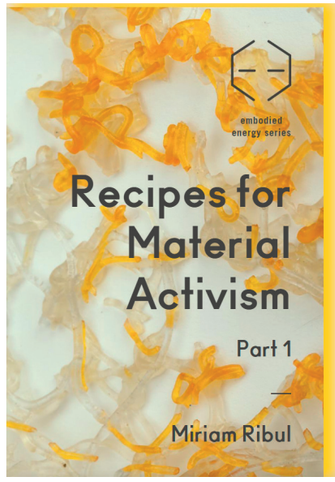


Image 99: Book "Recipes for Material Activism". Available at < https://www.materialactivism.com/recipes-for-material-activism>

Other common approach within the DIY universe are the kits: these usually come in small boxes containing the necessary elements for the production of a product. A quick Google search of the terms "DIY kit" provides us with approximately 608.000.000 results, ranging from electronics and robotics, to games, soap, and clothing. Kits come in several difficulty levels, for different skill and knowledge levels, but normally they have the same goal: assist in the process of producing something.

The idea of creating a kit to assist in the beginnings of a tinkering process that incorporated PIY fits well, both with the scenario criteria and the technical and sensorial characteristics mentioned previously. Besides, it could help in the distribution of the knowledge about DIY materials, and be used as study material in workshops, schools, universities or even be presented as scientific toys.

Image 100. DIY Gamer Kit – Technology Will Save Us. Available at <www.dezeen.com/2014/11/05/moma-acquires-electronics-products-diy-gamer-kit-technology-will-save-us-arduino-ototo>

Image 101. DIY Soap Kit – Arterno. Available at <arterno.com/product/diy-soap-kit>

Image 102. DIY Belt Kit – Nappa Dori. Available at <www.nappadori.com/diy-belt-kit>

16.4 Scenario

Users: Could be DIY enthusiasts, DIY materials researchers, for personal use or in lectures/workshops and anyone who would like to be introduced to the Tinkering method.

Production: Through partnerships with abattoirs, butcher shops and supermarkets, skin that would originally be discarded could be transformed in PIY.

Distribution: This material would be sold through an online platform.

Community: The platform would also be used as a sharing point for information and knowledge about the materials, creating a sense of community (also very present in the DIY universe).

Checklist of predetermined scenario criteria:

- The proposed application would valorise the raw material, repurposing parts considered waste, adding value to it;
- The proposed use of the primal matter would be sustainable, since PIY would be made from parts unused by providers;
- The kit would assist in the DIY process, by turning an experimental method into something friendlier, promoting curiosity in users, leading them to discover and allowing them to be surprised by the material, and by providing the security of a starting point;
- The variety in surface finishes, textures and combinations observed as technical characteristics of the material would be one of its positive traits when applied in a kit, since it allows a wide range of possibilities for the user.

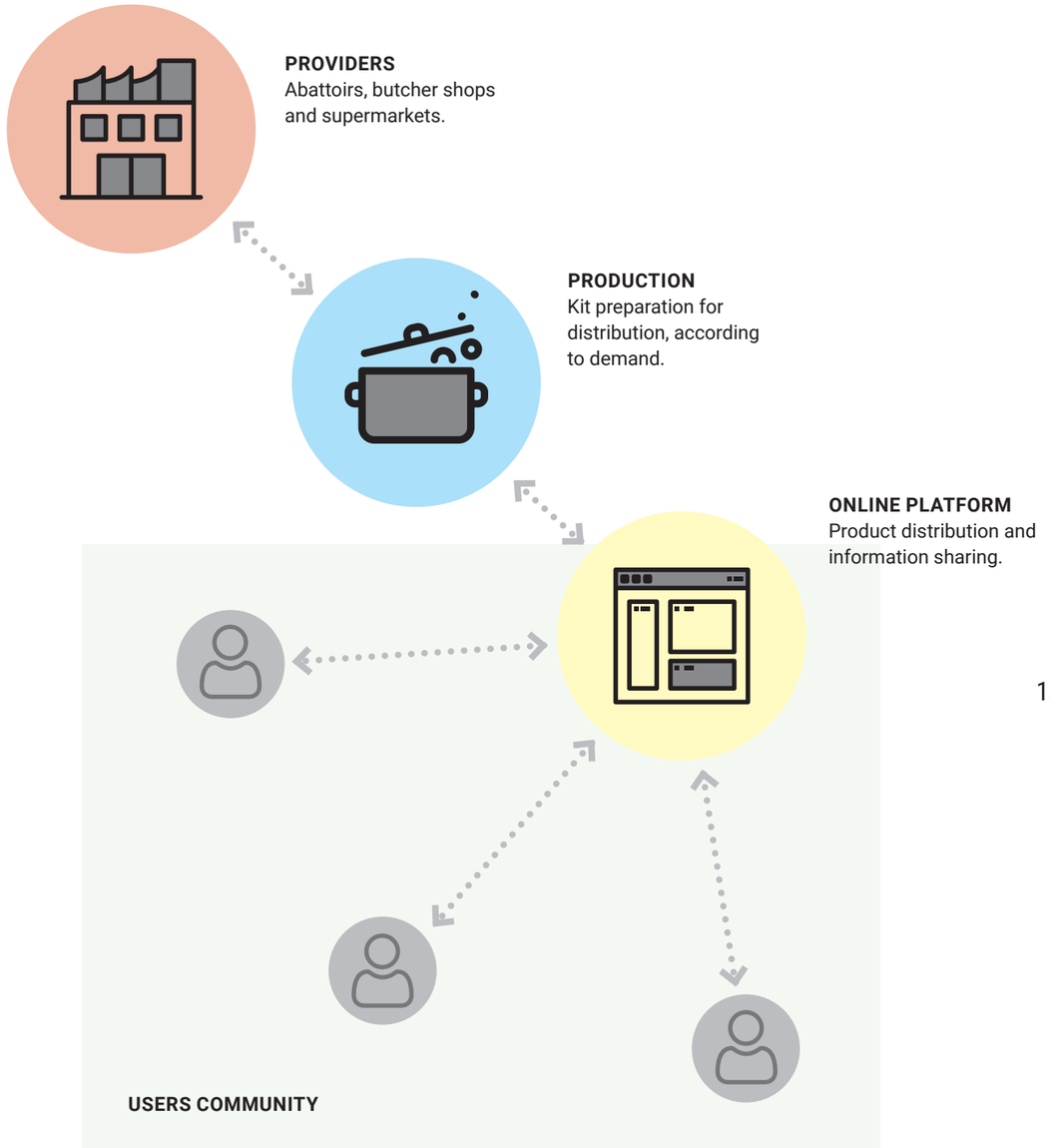


Image 103: Proposed scenario flow chart.

17.

Applications

With a developed scenario, we advance onto the designing of the proposed application: the kit. Its objective is to facilitate the initiation to the Tinkering process and DIY Materials. As such, it must be user-friendly and provide a starting point, so that the user feels safe in venturing through the process. However, the kit must offer space for the user to create – by themselves – their combinations.

17.1 Development and composition of the PIY Kit

Initially, the PIY kit would be entirely made from the material, so that it can be entirely used by the user. However, this proposition, could be at the user's disposal, if they can find elements to achieve the realisation of the experiment. Even though the tools are easy to access, this point could render the kit less friendly, disturbing the experience.

Image 104: Cast for the manufacturing of the first version of the kit

Image 105: Preparation of the cast for the first version of the kit

Image 106: Manufacturing process of the first version of the kit

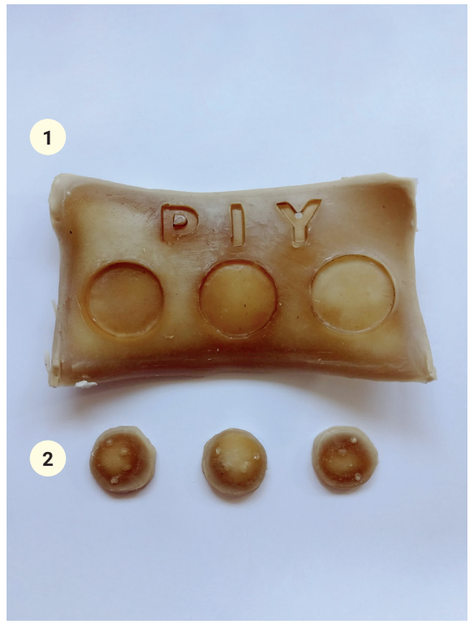


Image 107: Final result of the first version of the kit: 1 – stand and 2 – pieces of material to be melted

Thinking of a new proposition, previous experiences were analysed so that it resulted in basic kit components, so the experimentation process occurred in a satisfactory level regarding the goals of the kit. We achieved the following components:

- 100g of dry PIY, molded into a shape that facilitates the process, and stored in a heat and fridge-safe container, for reheating and cooling;
- 100ml glycerol;
- 02 food dyes;
- 01 measuring spoon;
- Instructions would be made available on the online platform, to reduce expenses and save material, and incentive users to use and participate in the platform/community.

Image 108: PIY Kit

Image 109: Kit details: PIY stored inside the heat-friendly container

Image 110: Kit details: 100g PIY portion, one of the kit components

18.

Conclusions

When the present work was started, its goals were to build a consistent profile of the material, and investigate possible application and use scenarios. Now, at the end of the research, considering the results and discoveries about PIY, it is possible to notice the material characterisation greatly evolved throughout the process.

Regarding the sensorial aspect, the test applied to users provided new perspectives about how PIY was perceived and how its characteristics could be used in projecting an experience. Furthermore, it was also possible to realise how the variable textures, solidities, odours and colours altered people's perceptions about the material. This is a rather positive aspect, since PIY allows a great number of combinations of these variables, which results in countless possible experiences.

Regarding the technical aspects of the material, the tinkering process and the data treatment allowed for the establishment of a recipe and a consistent manipulation of the material, which in turn enabled greater control over some characteristics, such as flexibility, opacity, colour, shrinking, etc. Besides, during laboratory testing, we were able to determine the traction resistance of PIY: relevant data for the characterisation of a material, and one probably much too difficult to discover through tinkering alone. Unfortunately, only this laboratory test was conducted; I do believe, however, further laboratory testing about the technical aspects of the material would be valuable for the project, and for the investigation of scenario and applications.

Lastly, application and scenario have proved to be compatible both with the method and with the material. The PIY Kit is an exploration tool that not only assists the use, but is also capable of valorising and amplifying the potential of the material, allowing other people to start designing with it.

Transforming PIY in an open-source material ensures that this work does not end in itself. On the contrary, it opens up to a new stage of exploration of its potentialities, which might grant great learning, not only about the material, but alo about the kit and how interactions with it in the real world would occur. This information can be employed to improve the PIY and its kit.

I conclude this article with the sensation that much was discovered, and much more is still awaiting to be discovered, since each interaction teaches something new. This is one of the greatest wisdoms I derive from the present work. Altering the way in which we design was not an easy task. Nonetheless, the Material Driven Design method enabled me to approach the project from a new perspective, and to devise something completely new.

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Lastly, I would like to thank my tutor, Prof.Valentina, who gave me the necessary support to conclude this work.

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