

Arenga Rainforest Sugar

Designing a tool to enhance the experience of
the Arenga Rainforest Sugar for coffee bar guests



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Master thesis
Designing a tool to enhance the experience of
the Arenga Rainforest Sugar for coffee bar guests

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Preface

I selected this assignment for my graduation project because it combines nicely my focus points of Sustainability, Food Design and Material Driven Design, which I chose to add to my Integrated Product Design master studies. I could learn a lot during the past 5 years studying in Delft. This graduation project is rounding off my student time and I feel well prepared to start working as a Industrial Design Engineer.

I would like to thank my great supervisors Rick and Bahar for supporting and guiding me through this project. I appreciated that you shared your knowledge and experience with me, gave honest feedback and that you pushed me to explore for me new areas and try out different approaches. You gave me inspiration and helped me focus and improve a lot.

I also want to thank *Forestwise* for the great and meaningful assignment and the big freedom you gave me.

The PMB staff was amazing support in the workshop to build my prototype.

I met a lot of very open and helpful owners, managers and waiters of cafés in Delft and Den Haag, who took time to give me feedback and valuable insights at different points during this project. Also fellow students participating in my user study were a big help.

My family, friends and fellow students were furthermore a huge help during the whole process, giving me feedback, inspiration and good tips.

I want to specially thank my boyfriend Christoph for your great support!

Summary

Forestwise wanted a suitable way to serve their Arenga Rainforest Sugar in Dutch cafés. This brown sugar comes from Indonesia and is a tasty, healthy and sustainable alternative to regular sugar. It is wild-harvested from the Arenga palm tree, which grows naturally inside the jungle. The Arenga sugar provides the local farmers with an income from their existing forests and motivates them to halt deforestation and protect biodiversity. This background story should be communicated to end-consumers.

The first analysis phase consists of research about the sugar's source, the context of use, and the sugar's characteristics. Applying the Material Driven Design method stimulates to not take the granulated, brown Arenga sugar as given, but play with texture, shape and process to find a more suitable way to serve it.

Synthesizing the insights into a Material Experience Vision and Design Criteria leads to a variety of ideas, categorised into 9 design directions. From those, 3 concepts are worked out. The stencil shaker concept makes use of the dark colour of the sugar and puts a surprise illustration, depicting the rainforest's biodiversity, on the milk foam of the café guest's drink. The rainforest globe concept is a decorative, round sugar pot from glass, depicting the eco-system of the Arenga tree and the rainforest. The selected concept of the sugar block grater lets the user transform traditional, hard sugar blocks into flakes.

A more specific vision is defined to develop this concept. The metaphor of a opening flower bud describes the desired user experience. The sugar should be perceived as natural and special. It is furthermore desired to let the café guests explore the background story of the sugar and get actively involved in it, feeling curiosity, pleasant surprise and virtuousness.

The final design proposal is a grater made out of bamboo, which is placed on the café's tables. It is filled with cylindrical sugar blocks with chocolate-like texture. The café guest can grate sugar flakes by rotating the base of the grater. A mechanism turns and pushes the sugar blocks against a knife with two blades, shaving off a layered spiral of flakes.

The sugar comes out at the top of the grater in the shape of a flower. The user can observe the sugar "growing" inside an illustration of the rainforest, which is engraved in the bamboo around. This lets the user experience how the sugar naturally grows inside the biodiverse rainforest in Indonesia, contrary to being cultivated in monoculture plantations. The background story of the sugar is illustrated with engravings on the outside of the grater, showing how the sugar is wild-harvested and processed. The café guests become part of the process by grating their own sugar flakes to sweeten their drinks. This drives a sustainable system of rainforest and local farmers. The sugar is presented as special and natural, in an attractive and novel way.

The concept is tested with a working prototype and evaluated by users and cafés.

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Introduction

This chapter introduces the project and its stakeholders. The problem definition and goal of the project are presented and followed by an overview of the final design, to show how the problem was solved. Afterwards the approach and methodology are explained to follow along the design process and understand how the design was developed. The project brief can be found in the appendix.

Project Description

This project is about developing a rainforest sugar-based product for *forestwise* (www.forestwise.earth). *Forestwise* is an Indonesian based company, providing sustainable alternatives for the forest communities in Indonesia. They help them to earn an income from their existing rainforest, instead of turning it into monoculture palm oil plantations. The company produces and promotes a range of products that are wild-harvested from the natural forest system, without harming it and are produced using zero-waste production systems.

Their current range of products includes Arenga Rainforest Sugar (used as food ingredient or in coffee/tea), Cold-Pressed Virgin Coconut Oil (used in food or cosmetics) and Illipe Butter (a cosmetic ingredient). This project focuses on the sugar products. The sugar is harvested from the Arenga palm tree, which naturally grows in the rainforest and requires this biodiverse surrounding. Rainforest sugar is made from the sweet sap of the Arenga tree, which can be tapped year-round and in vast quantities. The Arenga sugar is brown and has a light caramel-like flavour. Not only the taste of the Arenga sugar is unique, but also the environmentally friendly manufacturing process and the perceived health benefits (Stichting Masarang International, n.d.).

The project is focused on designing a product with the Arenga rainforest sugar for Dutch end-consumers, to be served in cafés to sweeten hot beverages. The starting point was granulated, brown Arenga sugar (see Figure 1).



Figure 1: Granulated Arenga sugar

Stakeholders

The stakeholders involved in this project are introduced in this chapter. The design *student* Klara Kohler selected the project, aligning it with her interests and learning goals. *TU Delft* provides the supervisory team and sets requirements for the formalities and content of the graduation thesis. *Forestwise* formulated the initial assignment and wants their products to be promoted and tell their story to the end consumer. They are interested in an innovative idea, which can be quickly implemented. The *cafés* play a big role for this project, since they are the customers buying the product and providing the context of use. Finally the *guests* of the café are the users of the product, who have to be able to understand it and the story behind. The *production* of the (sugar) product might be also taken into account and is depending on the design. *Distributors* can be interesting to take into account, in order to make use of the existing distribution channels of coffee and tea.

Problem Definition Goal

There is a rising interest and awareness about the origin and story of food ingredients and their impact on society and environment. People are looking to make more conscious decisions about their food. Nevertheless sugar is currently not much valued as resource and its origin and story is not often communicated.

The Arenga Rainforest Sugar has a positive impact on deforestation and the livelihood of forest communities in Indonesia. This is a story, worth sharing. The Arenga sugar is one of the sustainably wild-harvested rainforest products. Promoting these increases the forest's value and makes it economically beneficial for the local farmers to preserve the rainforest areas and the animals that live there and halts deforestation. That is an urgent issue because we are quickly losing big parts of rainforest, which has a huge impact on biodiversity and climate change. Due to its increasing consumption, coffee is one of the (future) drivers for deforestation (Conservation International, 2016).

The expected outcome of this project is an Arenga sugar based product, to be served with hot drinks in Dutch cafés. It will present the Arenga sugar in an interesting and appealing way, emphasizing its unique qualities. *Forestwise's* story about the sugar's background will be communicated to the end consumer. This will stimulate people to value the sugar and think about its origin. A physical prototype will be made, which proves the concepts feasibility, desirability and viability.

Final Design

The outcome of this graduation project is a tool to serve the Arenga Rainforest Sugar in coffee bars. Traditional hard sugar blocks are grated into beautiful sugar flakes by the café guests, to sweeten their hot drinks, such as coffee and tea. The detailed final design is presented at the end of this report (page 64).

The context of use for the sugar grater are cafés in the Netherlands. The focus lies on small speciality coffee bars with hip guests, offering a range of tasty, healthy and sustainable products with a transparent story (see “Product Context” on page 8 and “Target Group” on page 26).

The tool is placed on the table and café guests can use it to sweeten their drinks. It enhances their experience of the Arenga Rainforest Sugar and facilitates a new way of serving sugar (“Benchmarking” on page 10). The bottom compartment of the tool is filled with sugar blocks by the café personnel beforehand. The guest then only has to turn the bottom part of the tool, which pushes and rotates the stacked sugar blocks against knives (see “Mechanism” on page 68), shaving off sugar flakes (page 46), which come out on the top like a flower.

The Arenga sugar is sustainably wild-harvested from the rainforest on Borneo (Indonesia) by the local forest communities. The sugar is made from sweet sap, tapped from the Arenga pinnata palm tree, which naturally grows in the biodiverse rainforest, instead of monoculture plantations (see “Arenga Sugar Source” on page 12). This background story (see page 104) is depicted on the grater tool with engravings (Figure 3), showing the balanced eco-system of forest community and rainforest, both benefiting from each other. The café guest’s role is to keep this system running and have an impact with conscious consumption behaviour. While grating, the user can observe the sugar grow in the shape of a flower, inside the engraved rainforest (see Figure 2), same as the sugar palm naturally grows in the rainforest.

This way the sugar is presented as something special and natural and the user is stimulated to appreciate it through active engagement and the way the tool is held. The Arenga sugar is a healthy sweetener with a low glycemic index and a number of nutrients (“Arenga sugar characteristics” on page 16).

The sugar is packed in stylish paper rolls with the Arenga logo (page 75) and shipped from Indonesia to the Netherlands in compact, hard, cylindrical blocks, as traditionally made in south east Asia. Those blocks support the authentic image and help to differentiate the Arenga sugar from regular brown sugar and make its unique story more clear for the user.

The grater supports the natural appearance of the sugar and the material choice of bamboo matches the sugar’s source, since the farmers also use bamboo tubes to collect the sugar sap from the Arenga trees. The cylindrical shape fits the size of the sugar blocks and gives hints to the user about the rotational grating function. The grater also serves as a decorative element, drawing the guests’ attention and being a visual statement for the café’s sustainability efforts.

The design is evaluated (page 78) by user tests and interviews with personnel, managers and owners of cafés. The main parts of the desired user experience (see “Material Experience Vision” on page 22 and the more detailed “Vision” on page 40) could be confirmed. The Arenga Rainforest Sugar is experienced as natural, special and authentic with emotions such as curiosity, pleasant surprise, fascination and virtuousness. The message of a healthy, sustainable and transparent product was also conveyed by the grater.



Figure 2: Final Design, usage, sugar flower, working principle



Figure 3: Final design, details, engravings (“Arenga Rainforest Sugar” and illustrations)

Approach

The approach for this project is illustrated in Figure 4, showing the process in a chronological way, with the three big iterations as loops (1. Analysis, 2. Design Development, 3. Design Detailing). Each project step was stretched over a longer period and covered several times, resulting in a process with big and small iterations.

The analysis for example was first a very broad collection of information. Afterwards it was prepared for a presentation, which required to dive deeper into certain topics, structure them and draw conclusions from the insights. At the same time idea development was already started. Many insights could be used as inspiration and to refine ideas, resulting in 9 design directions. For the midterm meeting a first report was drafted, stimulating another iterative cycle, supporting the selection of concepts and refinement of them.

Three concepts were developed, from which one was selected and further detailed. A more specific vision for this concept was drafted and used to detail the design of a sugar grater tool, considering the user experience and integrating the sugar's background story in the different design elements. A functioning prototype was made to test the working principle and several models were made to define the tools shape and material. Studies were conducted to evaluate and improve the design.

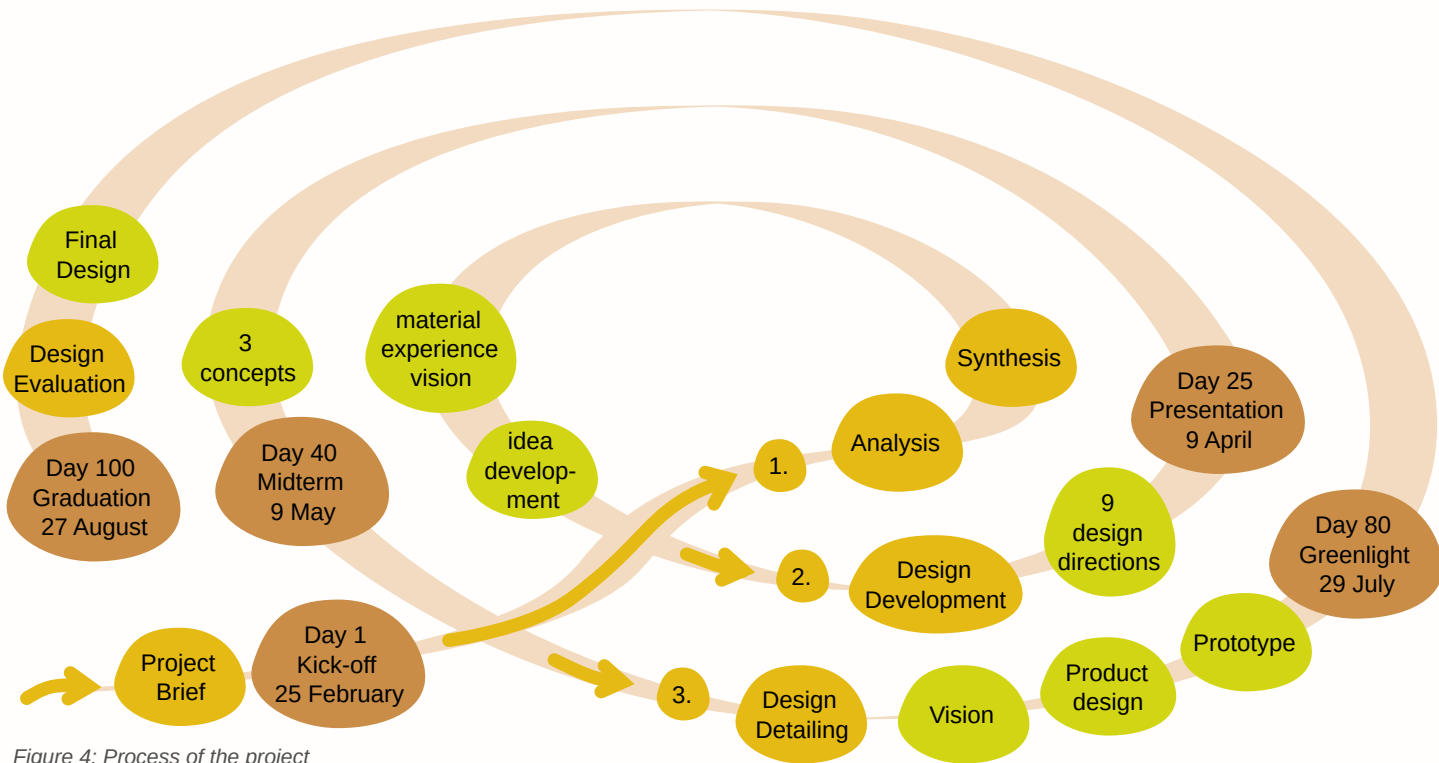


Figure 4: Process of the project

Methodology

Several design methods have been used and (partially) adapted for this project. Integrated Product Design serves as basis, which is combined with aspects of Material Driven Design and Food Design.

Integrated Product Design

Integrated Product Design is a continuation master of the bachelor Industrial Design Engineering at TU Delft. Design challenges are approached holistically, with focus on designing user-centered, innovative products and product service combinations. It is based on a balance between the interests of users, business and societal challenges, implementing technology in a meaningful way. It covers the entire design process, starting from a design brief and ending with a complete product that is feasible, desirable and viable and fit for mass or small series production. The focus lies on conceptualisation and embodiment design, using integrative approaches to cover aesthetic, ergonomic, engineering-related and environmental issues.

Material Driven Design

The Arenga sugar is seen as a material, and starting point for this project. The Material Driven Design (MDD) method (Karana, Barati, Rognoli, & Zeeuw van der Laan, 2015) is applied to further develop the material and find a suitable product application for the Arenga sugar. As opposed to classical product design the material serves as starting point, instead of first developing a product and then selecting a suitable material afterwards. The method facilitates designing for meaningful material experiences. This requires qualifying the material not only for what it is, but also for what it does, what it expresses to people, what it elicits from them, and what it makes them do. The process describes 4 iterative steps (see Figure 5). It starts with a material (or a material proposal), and ends with a product and/or further developed material.

Food Design

In Food Design designers' methods and approaches are applied to creatively solve food related issues considering agriculture, industrial processing, distribution and marketing, kitchen management, the eater, consumption situation and policy and legislation (Lee, 2017). Designers have trained specific abilities, enabling them to take the following four roles, which have added value for the food industry: "widen the scope of innovation projects, shape tools in order to engage others, structure and facilitate cooperation among team partners and integrate the knowledge from these different areas" (Schifferstein, 2016).

On the other side working with foods offers multiple ways to enrich the design discipline, opening up unique multisensory aesthetics and connecting designers with local cultures and social contexts, enabling people to connect with the origins of their food (Schifferstein, 2016). Furthermore food offers a rich set of prototyping materials, also facilitating the development of DIY materials (Parisi, Rognoli, & Sonneveld, 2017). Like any other material, food is something designers can explore in the workshop, and experiment with modelling its properties and qualities (Materials Experience Lab, n.d.).

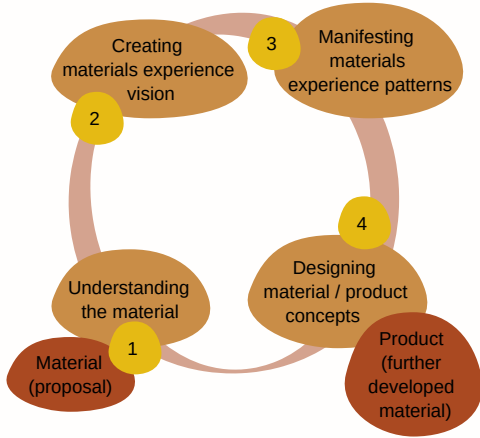


Figure 5: Material Driven Design

Analysis

This chapter gives an overview of the analysis, necessary to understand the context of the to be designed product, the source of the Arenga sugar and its material characteristics.

Product Context

The context of use of the final product is supposed to be cafés, coffee bars, lunch rooms, restaurants and hotels or such places, serving hot beverages like coffee and tea in The Netherlands. Here the owner, employees, guests (customers) and related trends and culture in general can be of interest. Internet research, observations and interviews with café guests, service employees, owners and managers were used to learn more about the design context.

The **personal preferences** on how people like to drink their coffee or tea vary a lot. Some people for example like to only sweeten the milk foam, whereas others prefer it if only the coffee below gets sweet, and other prefer not to add sugar at all. It was found that roughly half the people add sugar (or other sweeteners) to their hot drinks. Factors such as personal taste, quality of the drink, health concerns and way of presenting the sweeteners have a big influence on this percentage. Most cafés **present the sugar** in a rather boring way, mostly in sugar sachets and sometimes sugar cubes served per cup, or in jars, pots or sugar shakers on the table. Cafés prefer sugar packets, because they are convenient, clean and cheaply provided by coffee suppliers. Convenience is an important aspect for cafés, therefore they prefer to order everything (coffee, tea, sugar etc.) from one supplier and be able to compactly store and easily prepare and serve it. Brown (cane) sugar is becoming a popular alternative for white (refined) sugar. Honey is normally offered with (fresh) tea. Palm sugar is not well known yet and one café owner expected it to be very expensive. More awareness for organic and fair trade coffee is arising and in 2014 already half of the market share in the Netherlands was fairtrade coffee (CBS, 2014). Coffee plantation causing deforestation is nevertheless not well known and the deforestation free solution of shade grown coffee neither. Cafés increasingly try to be (perceived as) sustainable and guests are willing to pay a bit extra for this.

Market Trends

Market trends are identified and shown in Figure 6. A good summary is the statement on the website of the café Pistache in Den Haag: “Our mission is to provide clean, organic, fresh and tasty food for both naughty and healthy eaters.” (Pistache Café, n.d.).

Enjoyment

On one side people like to treat themselves and enjoy tasty food. “Consumers view food not only as a bundle of attributes like nutrients and sensory properties, but also holistically as a source of pleasure and happiness.” (Grunert et. al., n.d.). Hip coffee bars, design cafés and restaurants are spreading in the cities, serving delicious cakes, snacks and special meals. People increasingly spend more money on eating out; in 2017 Dutch people spent about a third of their money while going out for food and drinks (Foodservice Instituut Nederland (FSIN), 2018).



Healthy

On the other side people prefer to eat more healthy and natural, causing the demand for natural sweeteners to grow (CBI, 2016). Natural and authentic food ingredients are perceived as being healthier and safer than synthetic ones, therefore also synthetic sweeteners are losing momentum. There is a consumer backlash against added sugar, because of health concerns, regarding for example obesity, heart disease, tooth decay and diabetes (Ananda Venture, 2017). According to CBI (2016) there are also more consumers looking for products with a low glycemic index. The interest to experiment with alternative ingredients and the general exposure to it is also increasing (Ananda Venture, 2017), making more people interested in alternative natural sweeteners. Rising awareness about sustainability and the fact that people want to make a difference, favours organic and transparent products.

Many cafés use (tropical) plants as decoration and have natural interiors with bright wood. Another interesting trend is “blurring”, where for example shops and cafés are combined. This concept is implemented in several cities to make the shopping streets more lively (Heede, 2016). This is also in line with cafés promoting the origin of their products, displaying for example bags of their coffee.

Figure 6: Market trends

Benchmarking

The Arenga sugar is benchmarked with existing products and materials on the market. This market analysis helps to build further on what was already done before, inspire new ideas and find unique opportunities for the Arenga sugar.



Figure 7: Arenga sugar

Arenga sugar is a type of palm sugar. The broader term palm sugar is often used, without clearly indicating that the sugar may be also made of the sap of the palmyra palm, date palm, nipa palm or co-cos palm. The tastes and nutritional values are very similar, but the Arenga sugar brings advantages for harvesting. All palm sugar can be found in granulated form, as hard blocks, or syrup.

In the Netherlands, different types of palm sugar are available in Asian super-markets and in organic and health stores. The **granulated** Arenga sugar is mostly sold in plastic pouch bags (see Figure 7). Jars are sometimes also used to package granulated sugar or **syrup**. The sugar **blocks** are normally packaged in a roll of plastic. The simple designs give often hints about its source, depicting either the palm tree or an orangutan, and some packages have an organic or fair trade label and state the sugar's health advantages.

In Figure 8 a broader range of existing sweetener products are categorised in ordinary, more healthy, adding taste, special / exclusive, original and communicating a message.

Ordinary sweeteners are sugar packets with white or brown sugar, sugar shakers, jars, sugar cubes or rock sugar. Other sweeteners perceived as more **healthy** are for example cocos sugar, different palm sugars, agave syrup, maple syrup and honey. In China black sugar blocks with flower petals, herbs, spices and tea are mixed with hot water and seen as very healthy. Many sweeteners also **add taste**. A range of syrups with added flavours such as vanilla, hazelnut or caramel are also often offered with coffee. There are many ways how sugar can be served in a **special** and more exclusive way, but rarely found in regular cafés. **Original** ideas include using sugar as a cup, making shapes out of sugar foam (marshmallow or meringue), decorating cappuccino with illustrations using latte art or cacao, or interestingly shaped sugar pots or spoons. In some examples sugar is also used to **communicate a message**, mainly with images, or by giving the sugar or the container a special shape.



Figure 8: Benchmarking sweetener products

Arenga Sugar Source

The Arenga sugar from *forestwise* is coming from the rainforest of the Indonesian part of the island Borneo, West Kalimantan. It is important to understand where the Arenga sugar comes from and get more knowledge about Indonesia, its culture, the farmers harvesting the sugar, and about the rainforest, in order to be able to decide which part of the story to communicate to the end consumers.



Figure 9: Borneo

Forestwise

Forestwise (forestwise.earth) was previously called The Wild Bunch and is a social enterprise, based in Indonesia (Kalimantan). Their mission is to halt deforestation and keep the forest wild by protecting its biodiversity, instead of turning it into monoculture palm oil plantations. They support farmers to sustainably produce high quality, wild harvested, non-timber rainforest products, from existing forests and without harming the forest. Their current range of products includes Arenga sugar, cold-pressed virgin coconut oil (used in food or cosmetics) and Illipe Butter (a cosmetic ingredient). *Forestwise* currently mainly sells B2B to customers that use their products as an ingredient. They would like their products and story also to reach the end-consumer. By increasing sales of these products, they simultaneously increase the value of the forest and empower the forest inhabitants to keep protecting it.



Figure 10: Logo forestwise

Rainforest

Rainforests are the most biodiverse places on earth and home to more than half the world's animal species (Rainforest Alliance, 2016), even though they cover less than 5% of the earth's surface (Augustina, 2018). A century ago most of Borneo was covered by forest, but the island has lost half of its forest already and deforestation is continuing in an alarming rate (WWF - World Wide Fund For Nature, n.d.). Borneo is estimated to still be home to around 222 mammals (including 44 not found anywhere else in the world; endemic), 420 birds (37 endemic), and at least 15,000 plants, of which 6,000 are endemic (WWF - World Wide Fund For Nature, n.d.). Many of those animals and plants are depending on the rainforest. A well known species and easy to relate to are the Orangutans, who already lost big parts of their habitat, due to deforestation. A big driver for deforestation is palm oil production, replacing wild forests with monoculture plantations. This has not only big influences on CO2 emissions and global warming, but also affects the local climate and for example the drinking water quality.



Figure 11: Rainforest and biodiversity in Borneo

Arenga Palm Tree

The Arenga palm tree (*Arenga pinnata*, see Figure 12) is native to humid areas growing in coastal and tropical climate around the equator, especially in South-east Asia. The Arenga palm tree should not be confused with the oil palm, which is normally grown as monoculture and causing deforestation. The Arenga trees on the other side naturally grow in the biodiverse rainforest and can help reforestation, with amongst others their deep roots (over 12m) stabilizing the forest soil, preventing landslides, and resisting fires (National Geographic, 2015).

Wild-harvesting products from the Arennga palm trees can help to make it economically beneficial to preserve the rainforest areas and the animals that live there. On Borneo the local forest communities harvest the sugar, who belong to the native Dayak people having a rich tradition.

Tree

Arenga pinnata has a single trunk ranging up to 20m and a crown consisting of 15 to 20 huge leaves. The palm has matured after 7 to 10 years (depending on climate) and develops the first flower bunches (inflorescence), which means that tapping of the sweet palm sap can start (Elberson & Oyen, 2010).

Tapping

The Arenga palm is also called sugar palm, because of its high sugar content sap. The sugary sap can be wild-harvested year-round and in vast quantities. Twice a day a thin layer can be sliced from the end of the stalk on which (male) flowers are growing. If done properly, the tapping extends the life of the tree, by “stealing” some of the tree’s energy that was intended as storage for its seeds, and therefore delays the ripening of the fruit (Lavelle, 2011). Tapping is a skill that takes practice, but when well-cultivated, according to National Geographic (2015) in North Sulawesi it can earn proficient tappers up to \$2,500 per month, which is 8.5 times Indonesia’s per capita GDP. Only 5 Arenga trees are sufficient to provide the farmers’ family with their basic needs. In West Kalimantan alone, The Wild Bunch (now *forestwise*) can help at least 2340 farmers with a sustainable daily income, straight from their existing forest, from trees that are ready to be cultivated (The Wild Bunch, 2018).

Sugar Sap

The palm sap is transparent, with a sugar content of 100 – 144 g/kg, a pH of 7.0 – 7.4 and traces of ethanol (Lasekan et al., 2007). Other sources state even a higher sugar percentage of 17% and a daily harvest of 15-50 litre sap per day per tree (Hartman, 2014). PT Gunung Hijau (PTGH) Masarang researched how to control the volume of sap from the tree. Trees can be pushed up to 100 litre per day, but this level of tapping drains, and eventually kills the tree. Tapping 25 litre per day ensures a steady amount of sap (Ananda Venture, 2017).

The longer the storage time of the sap, the total soluble solid (TSS) content (sugar content) and pH value of the palm juice will decrease.

Processing

The fresh palm juice will decolourise into a dull colour (Faridatul Ain et al., 2014). It is therefore important to quickly process the sugar sap by cooking it to preserve it. Ultimately it must be boiled to evaporate the water and make sugar from it. The traditional way is to pour the thick syrup in moulds and let it harden (partially crystallized) to blocks of Gula Aren. If the pH is above 7 the syrup can be also completely crystallized to granulated sugar, still a bit sticky, because of the molasses. Instead of making sugar, the sap can be also fermented to for example palm wine or to make ethanol, which can be used as fuel. The fruits can be also eaten and the roots and flowers traditionally find medicinal uses (Ananda Venture, 2017). At the end of the tree's life cycle its wood, fibres (e.g. for bio-composites) and leaves can be used as building material.



Figure 12: *Arenga pinnata*: sap to sugar

Arenga Sugar Characteristics

The Arenga sugar must be understood as material, therefore its composition, properties and processing possibilities are explored. This helps to find a suitable way to present it in cafés.

The Arenga sugar consists of 94.2% sucrose and 0.6% other sugars. Next to this per 100 g it contains 0.2 g Fat, 2.5 g Protein, 1.1 g Fibres, 13.2 mg Vitamin C, 1.12 µg Vitamin B12, 3.3 mg Calcium, 36.7 mg Magnesium, 0.7 mg Phosphate, 760.0 mg Potassium, 4.1 mg Sodium, 0.9 mg Iron and 0.2 mg Zinc (The Wild Bunch, 2018). Arenga sugar is seen as 'superfood', containing 50 times more minerals than white sugar, three times more potassium than bananas, plus vitamin C and B12. It is a more healthy alternative sweetener to regular white cane or beet sugar. Its low glycemic index (GI) is almost half that of white sugar and honey, making it diabetic-friendly, because it takes longer to process the sugar, causing blood sugar levels to rise only slowly (The Wild Bunch, 2018).

The biggest part of the Arenga sugar is sucrose, which is the scientific name for table sugar and is a polar compound made of carbon, hydrogen and oxygen (C12H22O11). Sugars are categorized as monosaccharides or disaccharides. Disaccharides are made up of two, linked monosaccharides and broken back down into the latter during digestion. Sucrose is a disaccharide consisting of one glucose and one fructose molecule. Glucose is a simple sugar or monosaccharide and the body's preferred carb-based energy source (Macdonald, 2016).

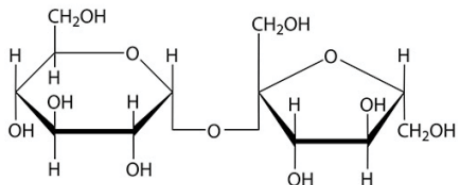


Figure 14: Sucrose (Glucose left and Fructose right)

Process Taxonomy

By tinkering with the material and analysing online references (e.g. tutorial videos) the sugar's processing possibilities were explored. This helped to understand how the material behaves and reacts to certain processes and to discover what unique properties can be created. Some processing steps are particular for the Arenga sugar, whereas most is possible with different kind of sugars.

To keep sugar from re-crystallizing, part of it must be inverted, which means that sucrose is split in fructose and glucose (World of Molecules, 2016). This can be partly achieved by boiling (at 114°C) or adding for example glucose syrup. Crystallization can be also prevented by lowering the pH to under 7 with for example a bit of vinegar or lemon juice.

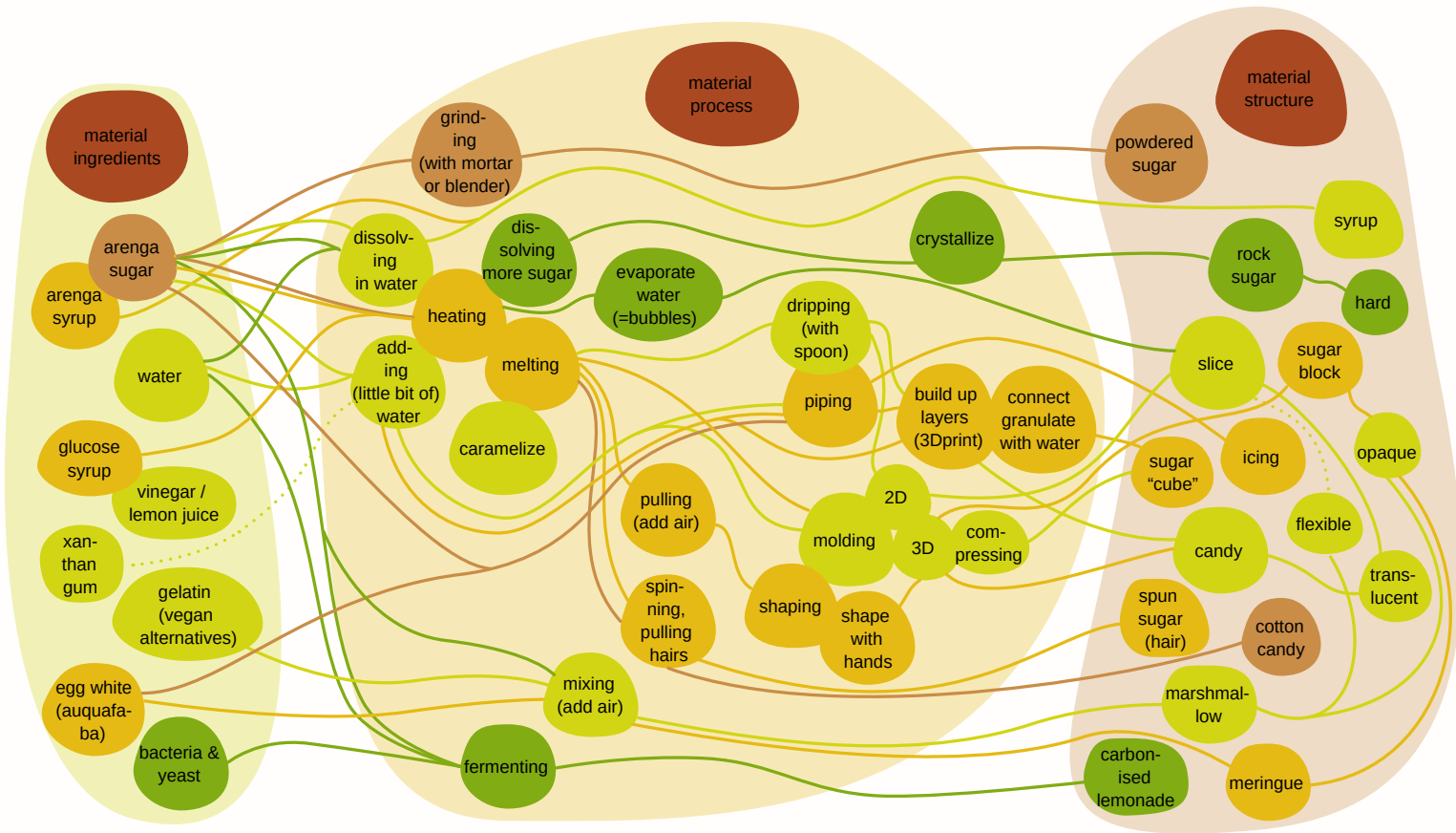


Figure 15: Process taxonomy

The material ingredients are kept basic, with mainly using pure granulated Arenga sugar. In some cases water is added, or agents to prevent crystallization or to make it flexible or foamy for example.

The processes are mainly about changing the texture, taste and ultimately shaping the sugar two- or three dimensionally.

The end result can range from fine powdered sugar over normal granulated sugar to big rock candy, and from airy marshmallow, meringue and cotton candy to syrup and glass like sugar, ranging from soft to hard. Some results of the tinkering are shown in Figure 13, at page 17 (Technical characterisation) and at page 20 (Experiential characterisation).



Figure 13: Material tinkering

Technical Characterisation

The material's technical properties are highly influenced by the processing and what ingredients are added to the Arenga sugar.

Heating

Sugar does not have a clear melting point, because it does not melt thermodynamically when heated, but loses its crystalline structure due to the kinetic process of thermal decomposition (termed apparent melting) (Lee, Thomas, & Schmidt, 2011). According to Schmidt the apparent melting point of sugar is depending on the heating-rate (University of Illinois, 2011). When decomposed sugar is further heated (around 180°C) it caramelises. With the Arenga sugar the caramelisation (and potentially burning) can partially already appear at lower temperatures, because of the molasses and other impurities.

Crystallinity

Depending on the pH and the degree the sugar is inverted (split in fructose and glucose) it can have a non-crystalline (amorphous) structure. Crystals grow in supersaturated solution and can range from very fine to coarse.

Density

The density of sucrose is 1.59 g/cm³, but with the Arenga sugar it is also depending on the humidity (water content) and its processing, as for example being compressed or foamed. The packaging weight is also depending on the shape.

Dissolving

Adding granulated sugar to water, makes it break apart because the water molecules are attracted to the sucrose molecules through intermolecular forces. Each sucrose molecule is surrounded by water molecules and is carried off into the solution. The dissolving process happens in two steps, where first the water molecules bind to the sucrose molecules; and second the water molecules pull the sucrose molecules away from the crystal and into the solution (Husband, 2014). This process is accelerated in hot water and hot water can solve a higher percentage of sugar. Arenga sugar (and brown sugar in general) was observed to dissolve slightly quicker than regular white sugar, because of its finer structure and higher moisture content. With sugar cubes and other candy like shapes the solution time also depends on the shape, contact area and density.

Moisture

Sugar draws humidity because water and sucrose are attracted to one another based on the attractions of opposite charges. It was observed that the Arenga sugar products draw humidity from air contact and become sticky. Adding Xanthan gum reduced this effect and glucose syrup made it worse, same as inverted sugars are very hygroscopic. When granulated Arenga sugar is left at open air it becomes hard and forms lumps. For brown sugar this is explained by the drying out of the moist molasses, which makes the sugar crystals stick to each other.

Stiffness

The material's stiffness can be also highly influenced by processing. The candy with water, glucose syrup or Xanthan gum are more flexible and can almost behave like a (slow) liquid. More glass like, stiff objects can become flexible after drawing humidity. Sugar cubes and other crystalline structures can be very brittle, which is also influenced by how well the crystals are connected (e.g. pressing sugar cubes).



Figure 18: Technical characterization

Experiential Characterisation

Experiential characterisation is about investigating how a material is received, what it makes people think, feel and do. The Material Driven Design method (Karna et al, 2015) presents a list of questions in the MA2E4 tool kit, that guides the understanding of the four experiential layers: sensorial, performative, affective and interpretive. This tool kit was used to get detailed insights about a series of results from tinkering processes (see samples in Figure 18).

Furthermore the granulated sugar was presented in a jar and labelled as sugar at coffee bars and coffee machines at TU Delft campus. Observations and short feedback discussions during several days gave insights about how people receive the sugar as first impression and with their hot drinks. Most people reacted a bit hesitant when seeing the granulated brown sugar, being surprised that it is so dark and thinking that it is for example cinnamon, spices, cookie crumbles or chocolate. Many people also associated it with other brown sugars and thought it was “Basterd” sugar, brown cane sugar or coconut sugar. Most people first shook the jar and smelled the sugar. Reactions on the smell were divided, some really liked the smell, whereas others were negatively surprised. Carefully tasting a tiny bit pure sugar gave rather positive reactions and people described the noticeable different taste as caramel, coffee, malty, but overall sweet. When adding the sugar to the coffee it was perceived as sweet and not much difference to regular sugar was noticed.

All reactions are summarized and categorised in the four experiential layers in Figure 18.

A general conclusion is that it is very important to find the right balance between familiar and different. People should be able to recognise and understand that the Arenga sugar can be used as sweetener, to overcome the first hesitation. If the first impression is positive (mainly influenced by look and affective experience), people are curious to find out more. To emphasize this curiosity it is fine if the sugar has unknown and surprising aspects too.

It could be interesting to use the performative experience in the design, such as breaking a piece and crumble a slice or block of sugar. Also shaking the jar can be inspiring for designing the product interaction. The in the first place negative stickiness of the sugar candy (sensorial/feel) after air contact could be also used as something positive in the design.

The unique quality of the Arenga sugar having a distinct scent can be also used to distinguish it from odourless regular white sugar.



Figure 19: Experiential characterization

Synthesis

The information gathered from the analysis is synthesised in an iterative process to create a material experience vision, design criteria and define the target group. The synthesis presented in this chapter is preliminary and still relatively broad, because a more specific focus is only chosen later with the concept selection.

Material Experience Vision

In step 2 of the Material Driven Design method a material experience vision is created, which is “an encapsulation of material experience and technical characterisation as a cohesive whole”, envisioning “the design intentions for ‘new’ materials experience” (Karana et al., 2015).

This material experience vision is used for the first design phase, described in the next chapters, where design directions and concepts are presented. In the second phase of the project, where the selected concept is detailed, another more specific design vision will be presented (see page 40), describing the desired experience and interaction with a metaphor for the sugar grater.

The material experience vision is drafted by answering a set of questions suggested in the Material Driven Design paper (Karana et al., 2015) and building the basis of Figure 20.

Technical & Experiential

The Arenga sugar's unique technical qualities, which should be emphasised are its sweet taste, low glycemic index and high nutrients content and the variety of properties possible through processing. Its interesting unique experiential qualities are the dark brown colour, its scent and the natural and curious appearance.

Context

The material would make a positive difference in the context of cafés and coffee bars, where it can add to the coffee or tea experience.

Interaction

The café guests would interact with the Arenga sugar in an active and engaging way, but partially also in a more passive way observing and discovering.

Contribution

The Arenga sugar's role is to communicate its background story and create awareness for and protect the rainforest.

Interpretive & Sensorial

The material should be interpreted as natural and special and sensed as sweet (smell and taste) and delicate (look).

Affective

The material should elicit curiosity, appreciation and surprise with the café guests and give them a good feeling.

Performative

The Arenga sugar should invite people to interact with it, change its texture and dissolve it in their drink to taste it.

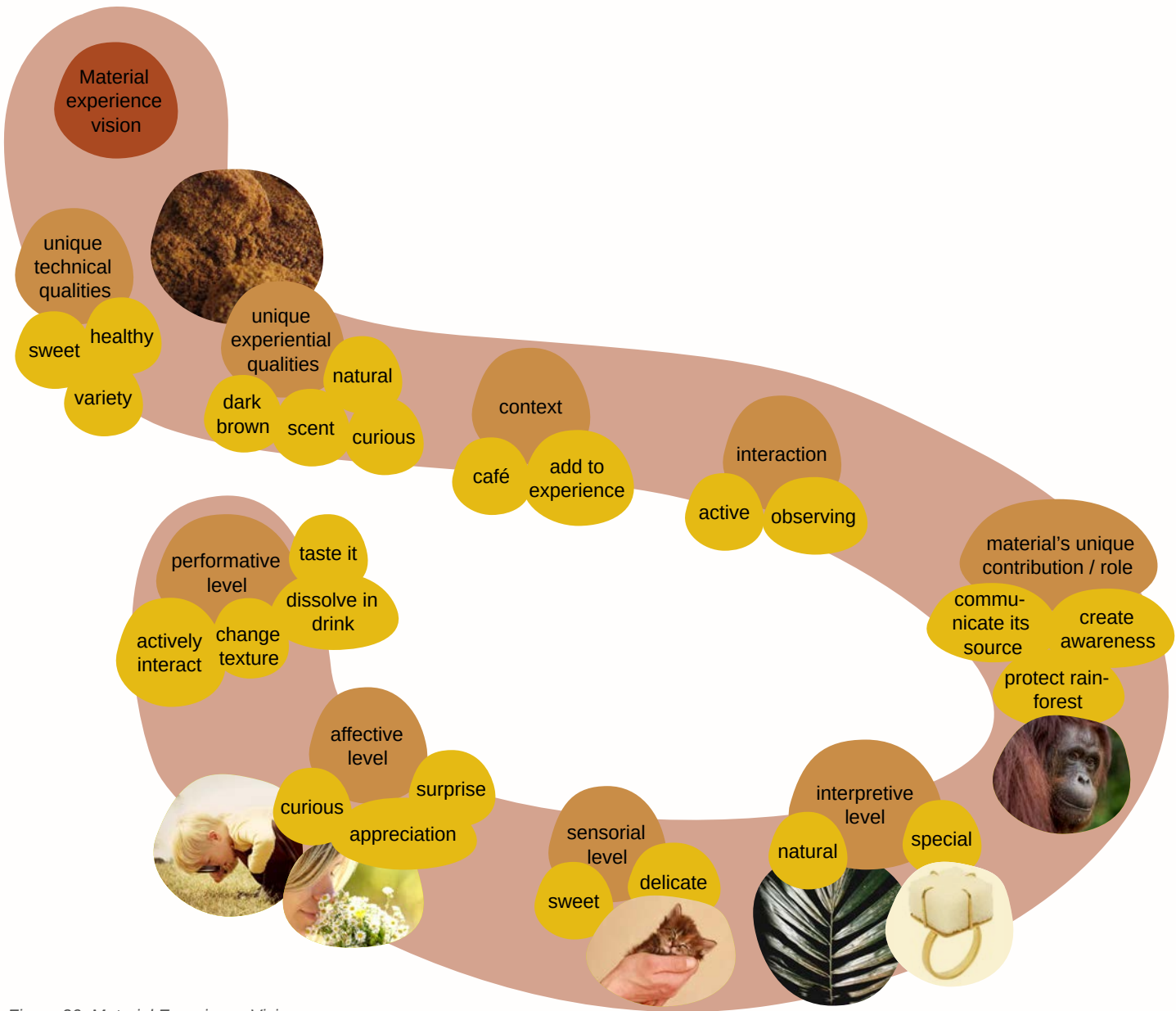


Figure 20: Material Experience Vision

Design Criteria

From the analysis many requirements for the product design could be derived. In Figure 19 the most important design criteria (yellow bubbles) are mapped with the different elements of the project (green bubbles). This first collection of broad design criteria is further specified later in the second phase of the project for the design detailing in a programme of requirements (page 62).

Source

Related to the source of the Arenga sugar, it is required that *forestwise*'s story about the role of the Arenga sugar for the rain-forest (animals & plants) and the people is communicated to the end consumer (café guest). Furthermore a steady sugar demand is required to guarantee a reliable income for the farmers. The production of the sugar product (and possibly related tools and packaging) should be as much as possible taking place in Indonesia to create work locally. This sets high demands on quality control and clear production instructions.

Packaging

It is important to package the sugar safe and airtight, to maintain its quality. The products should be also able to be packaged compactly, for more sustainable transportation. Ultimately the (inner, small batch) packaging can also be used to be presented to the customer and should therefore provide information and look attractive.

Supplier / Distributor

In case the sugar will be distributed through existing channels for coffee and tea (convenient for cafés), it could be considered to add branding (advertisement) possibilities to achieve a more competitive price. In order to be able to compete with regular (cheap) sweeteners, it is important that the Arenga sugar is offered with an added value for cafés and guests.

Café Guests

The design should add to the guests' coffee or tea experience and inform them and create awareness about deforestation. A second layer with more information (for example online) should be also provided for interested guests. The product must be easy to use and be balanced between being perceived as familiar and new, regarding both look and taste. A hand made and natural look should be achieved, and the product should be seen as sustainable and healthy. It should be possible for guests to sweeten their drinks according their preferences (foam or coffee) and adapt the amount of sweetness added, without creating waste.

Furthermore must the sugar dissolve quickly in the drink and be suitable for different kind of hot beverages. It must be safe (food safety) and without much effort to serve the sugar, potentially refill it and conveniently store it. A suitable pricing strategy must be found for guests and cafés, justifying the extra price with added value. The look of the design must match the cafés' style or allow for customisation. The first design will be focused on cafés, but should be adaptable in the future to suit hotels, restaurants and potentially also offices or home usage.

Sustainability

Throughout all aspects of the design, sustainability must be considered and a positive impact on environment and people is desired. This implies a honest design and is in line with the vision of *forestwise*. Integrating sustainability in the project is also required to be able to graduate with the annotation 'Technology in Sustainable Development' at TU Delft. The fact that this is an Integrated Product Design graduation project also requires an innovative product as outcome, which is feasible, desirable and viable.

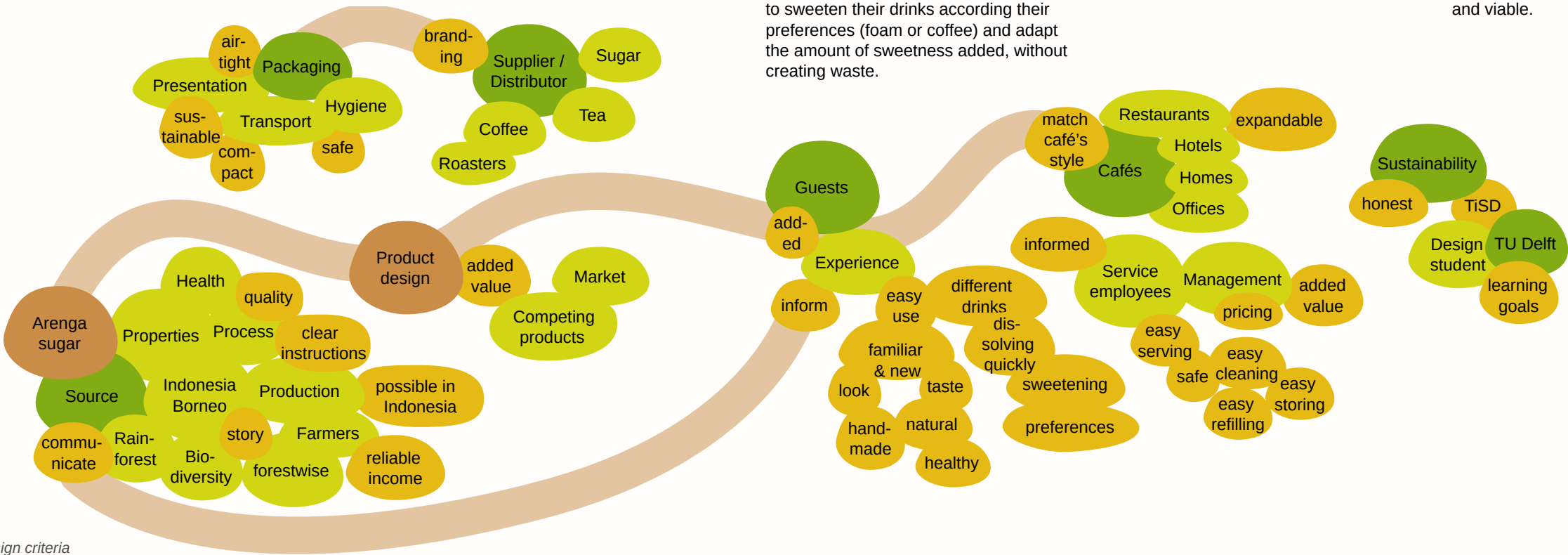


Figure 21: Design criteria

Target Group

The target group for the product are the guests of cafés (see Figure 22). The focus is put on individual cafés and small chains, lunch rooms, and speciality coffee bars. The cafés are nicely decorated and have a comfortable and personal atmosphere. The guests are hip and like to eat healthy but tasty. They prefer sustainable products, but are not extra conscious. This decision is done to reach a wider mass and also address people, who would not do much effort to find sustainable solutions.



Figure 22: Target group

Design Directions

Many ideas were generated and structured into the following 9 design directions: 3D shape, pot, shaker, slice, block, syrup, foam, lollipop and cookie (see Figure 23 and Figure 24, next page). The design directions are based on a variety of different textures and shapes of the sugar, resulting from the process taxonomy (page 16) and combined with suitable ways of serving.

3D Shape

This idea is about making sugar cube like portions by either pressing granulated sugar with some water or pouring sugar syrup (with very low water content) in a mould. Three dimensional shapes are possible, depicting for example an orangutan. They can be either served per cup (open or packaged) or be offered on the table in a sugar pot with pincers, or in a special dispenser.



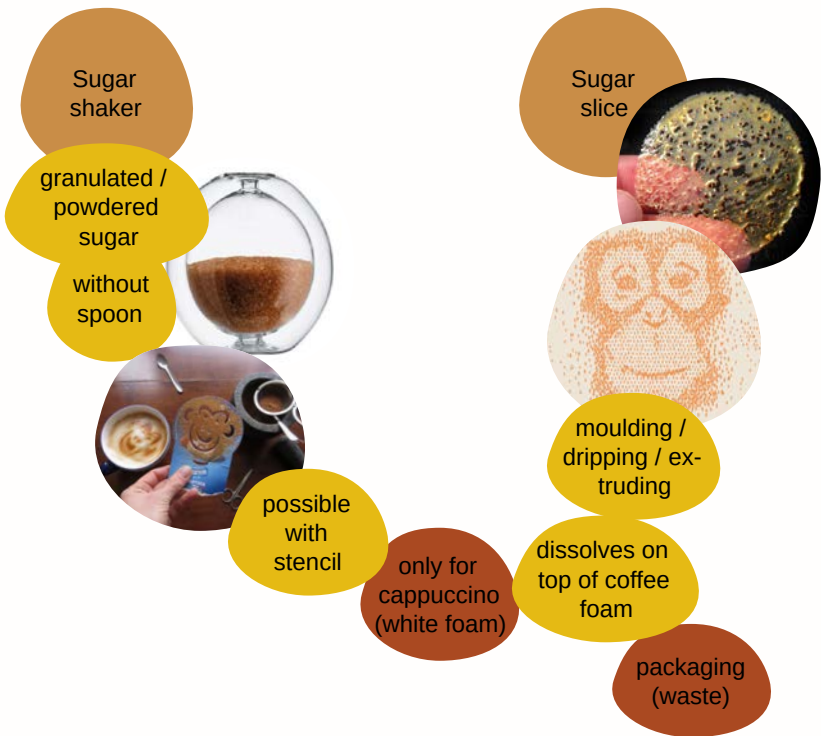
Pot

Granulated sugar can be offered in a pot on the table. It needs to have a lid in order to store the sugar airtight and the sugar must be served with a spoon. The story can be nicely integrated in the shape and look of the pot and possibly also the spoon.



Shaker

A shaker can be used for granulated sugar to serve it without the need of an extra spoon. Turning around the shaker normally gives one portion of sugar. With powdered sugar it is also possible to "shake" the sugar through a stencil, making a pattern or illustration on the coffee foam.



Slice

A one portion slice of sugar can be made by moulding, extruding, or dripping (molten) sugar in a pattern or illustration. It can be placed on top of coffee foam, leaving an illustration in several shades, which is slowly dissolving and this way sweetening the drink.



Block

A bigger block of sugar can be made by either pressing granulated sugar with some water or pouring sugar syrup (with very low water content) in a mould. One solid block can be produced, which is served in a handy tool to grind sugar flakes. Alternatively a mould with predefined breaking lines can be used. Guests can break off pieces of sugar (with sugar nips / pincers), similar to chocolate bars.

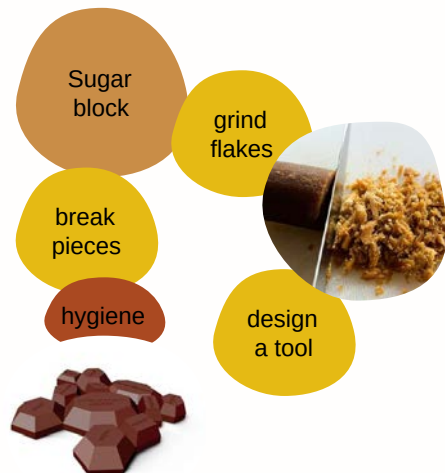
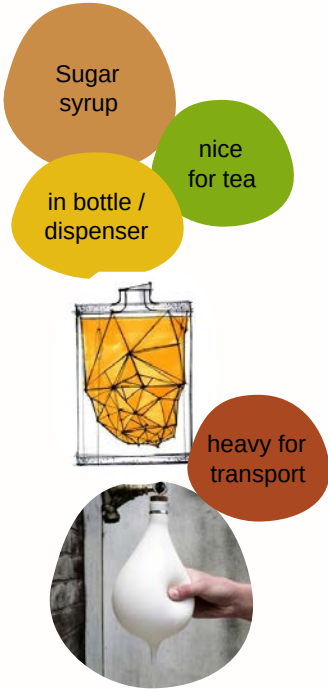


Figure 23: Design directions 1-5 (title, description, advantage, disadvantage)

Syrup

Syrup can be made by either diluting sugar in water or by not completely evaporating the water during sugar production. It can be served in an interestingly shaped bottle or in a dispenser and also nicely used to sweeten tea.



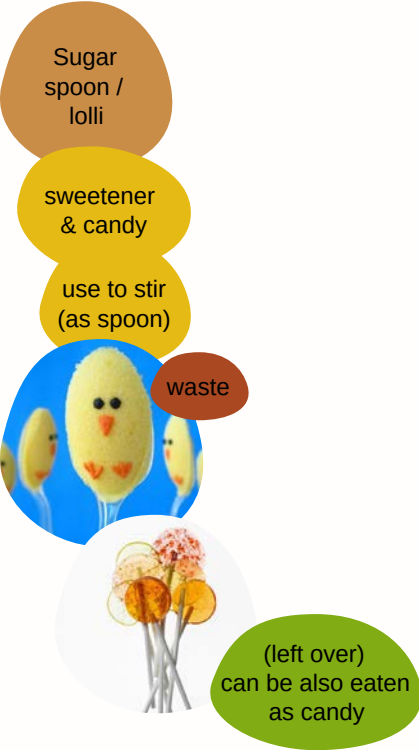
Foam

The sugar can be made airy (foam like) either by making cotton candy or mixing sugar with an agent as egg (meringue) or gelatine (marshmallow). This can be served on top of a hot drink. The increased volume can decrease sugar consumption, but it would be preferable to make the “foam” at the café (or close by) because of inefficient transportation of a low density product.



Lollipop

The sugar can be offered as a lollipop or a candy on a spoon, integrating directly something to stir the drink. In case the drink is found to be sweet enough before dissolving all the sugar, the remaining can be still eaten as a lollipop candy.



Cookie

The cookie, which is often served with the drink, can be integrated with the sugar. Part of the cookie can be made of or covered with sugar. This sugar part then dissolves when dipping the cookie in the drink. The shape of the cookie can be used to communicate the story.



Figure 24: Design directions 6-9 (title, description, advantage, disadvantage)

Concepts

The following three concepts were further developed from the idea directions sugar shaker, sugar pot and sugar block and selected because they seemed the most interesting, feasible and possible to fulfil all the design criteria.

Stencil Shaker

The stencil shaker concept is filled with powdered Arenga sugar and placed at the café's tables. When guests want to sweeten or decorate their drink, they place the shaker on top of their cup, where it rests on the cup's rim on its three feet. When the ball on the top is pulled, an internal mechanism gets activated, which stirs the sugar to break potential lumps and pushes one portion of sugar through a sieve and then through a stencil. A surprise illustration (the pattern of the stencil) will come out on the drink and will nicely decorate for example a cappuccino with frothed milk. This design makes use of the dark colour of the Arenga sugar by putting a high contrast illustration on the white milk foam, which slowly dissolves, creating gradients. This design is mainly suitable for cappuccino or latte macchiato. Regular coffee or espresso sometimes also have enough foam to carry the decoration, only the colour contrast might be lower. With tea it is nevertheless not possible to show the illustration.

The stencil is interchangeable and can be different at each table, surprising the guests. The illustration will depict animals and plants from the rainforest, to communicate the source of the sugar. More detailed information will be printed on the top and side of the sugar shaker. The stencils are easy to update (with new sugar deliveries) and special stencils can be offered to the cafés for branding purposes or seasonal activities.

In order to add more sugar to the drink, another button (on the side of the cylinder) can be activated to give a "sugar boost" coming out on the side (bottom), to not destroy the foam and the illustration. More details and alternative ideas are shown in Figure 25.

Similar products are already on the market for decorating with cocoa or cinnamon powder. Current designs can be though improved regarding usability and precision and adapted for the Arenga sugar, for easy and fun usage for guests in a café. The tool's shape, material choice and decorations should be also designed to support the sugar's background story and fit the materials experience vision.

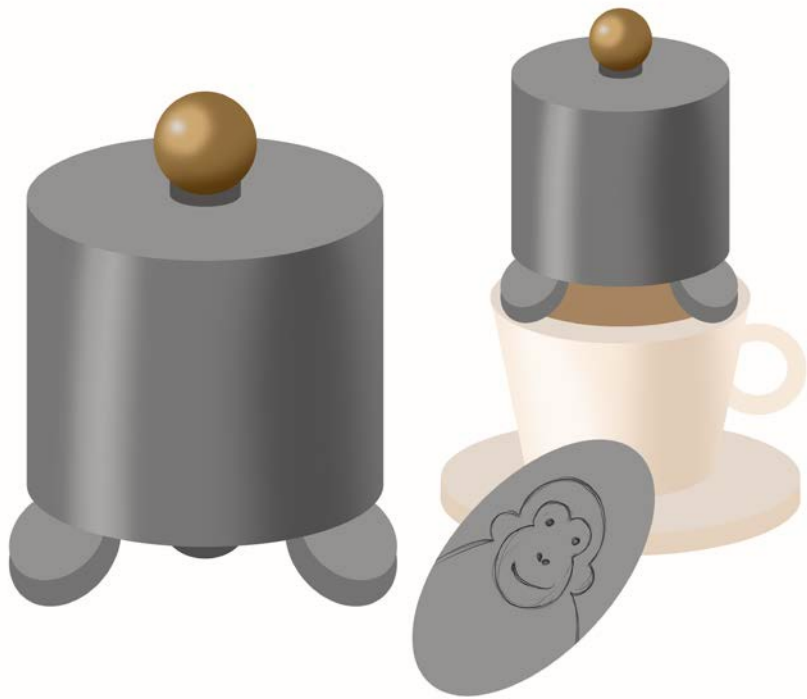


Figure 25: Stencil shaker

Rainforest Globe

The rainforest globe (see Figure 26) is a sugar pot inspired by a snow globe. The jar is filled with granulated sugar and stands on its lid on the café tables. The sugar will look like soil, providing the basis for a healthy rainforest. The outside of the glass globe is decorated with (real) leaves and trees and has many details to discover, such as flowers and all kinds of animals, showing the richness of the forest. The rainforest globe is a decorative element, potentially replacing flowers etc. on the table. Standing on the table it invites people to interact with it and shake it, serving as a conversation starter. On the bottom of the lid more information about the sugar's source is provided.

People who want to add sugar to their drinks can grab the globe, turn it up side down and unscrew the lid. A spoon is attached to the lid, turning and breaking sugar lumps, while opening the lid. It then can be used to scoop sugar to the cup. Integrating the spoon in the pot ensures that it stays clean and people do not use their own used spoon to serve sugar. This spoon represents an Arenga palm tree, which same as the depicted animals need the rainforest around.

The screw top lid ensures that the sugar is stored airtight and the wide opening facilitates easy refilling. The globe is made of glass, allowing to see when it needs to be refilled and is easy to clean. The spoon can be wood, porcelain or stainless steel. The (outside of the) lid can be made of natural material such as wood (bamboo), clay or stone and refer to the Arenga tree's important roots.

The sugar globe is easy to use and does not require any complicated mechanism. The regular granulated sugar can be used.



Figure 26: Rainforest globe

Block Grater

This concept (Figure 27) is a tool to grate and serve traditional sugar blocks or loafs (gula aren). A cylindrical sugar block (produced for example in a bamboo mould) is placed in the bottom of the grinder, which is standing on the café tables.

The bottom vessel is made of glass to see the sugar (and when it needs to be refilled). It has thick walls to be heavy as a usecue to leave this part on the table and only move the upper part. The upper part is made of stainless steel and has a grate blade on the bottom, touching the top surface of the sugar block. By turning and pushing the top part, sugar flakes are grated and collected in the upper part.

This part can be taken out and be used as a spoon to scoop the sugar into the cup. Grooves on the bottom of the glass vessel ensure that the sugar block is fixed in place and not turning with the rotational motion of the upper grating part.

Alternatively can the design be also a closed cylinder, similar to a pepper mill or cheese grater.



Figure 27: Block grater

Selection

The three concepts were evaluated in order to be able to select one design to further develop in the next phase. Evaluation was done by presenting the concepts to and asking feedback from the stakeholders. Potential users (café guests), owners and employers of 10 different cafés in Delft and The Hague, the projects supervisors and Dirk-Jan Oudshoorn and Arjan Verschoor from *forestwise* were all asked for feedback. Furthermore it was reflected back on the initial analysis and the design criteria where checked. The concepts generally can fulfil the requirements and it is possible to align them with the material experience vision. Some aspects however were still kept relatively open with the concepts and would need to be developed further to completely match with the criteria and vision statement.

The strengths and weaknesses of each concept are shown in Figure 28, which is a variation of the Harris Profile (Boeijen, Daalhuizen, Schoor, & Zijlstra, 2014, p. 139), where the criteria are ranked, with the most important one on top. Scores are given from -2 to 2 to prevent neutral scoring. A visual representation can show to which side “the tower would fall” to make a selection between conceptual designs.

The first criteria is that the sugar’s background **story** is integrated in the design. The stencil shaker achieves this as long as rainforest illustration stencils are used and more decorative elements can be added to the body. The rainforest globe highly integrates the story by depicting the whole ecosystem. The block grater is still a very plane design without making people experience the story. It currently scores low on this criteria but the shape can be redesigned and decoration can be added.

It is important that the design is perceived as **clean and hygienic** to make it more appealing to the café guests. The stencil shaker may be perceived as hygienic, because it is closed, but it could happen that milk foam touches the bottom of shaker. The integrated spoon with the rainforest globe makes people not use their own used spoon, but nevertheless is the sugar openly accessible. The block grater can be made closed so that the guests cannot touch the sugar block.

The third criteria is how easy the design is to use and **understand**. The Stencil shaker requires some explanation, because it has to be placed on top of the cup, and two portion sizes are possible (decoration and sugar boost). The globe design is relatively simple, but it may not be clear that it is sugar and edible and the globe has to be turned around before opening. The sugar grater is unknown but simple and similar to a pepper mill.

The Arenga sugar should be used for **coffee and tea**. The Stencil shaker is though only working on plain milk foam and not suitable for barista coffee with latte art or tea. The rainforest globe design works with all (hot) beverages like normal sugar, but might be less likely to replace honey, normally served with fresh tea. Same counts for the block grater, but since the sugar flakes are perceived as different and special they might me also used to replace honey.

It is very difficult to make a choice in this stage of concept development, were some points are still to be further developed. It becomes visible in Figure 28 that no concept is a very clear winner. The block grater scores only slightly better than the others, since it is weak on the first criteria. It is though decided to further develop this concept of the sugar block grater and look for ways how to better integrate the story in the design. For this, valuable elements from all the different ideas may be taken to improve the sugar grater concept. This concept is innovative and special and gratifying the traditional sugar block is authentic and conveying an artisanal style. It allows also to distinguish the Arenga sugar from regular brown sugar and therefore making its unique story more clear to the end consumers. Using the sugar blocks instead of granulated sugar also gives less problems when drawing humidity, making it less critical to keep the sugar airtight on the café tables.

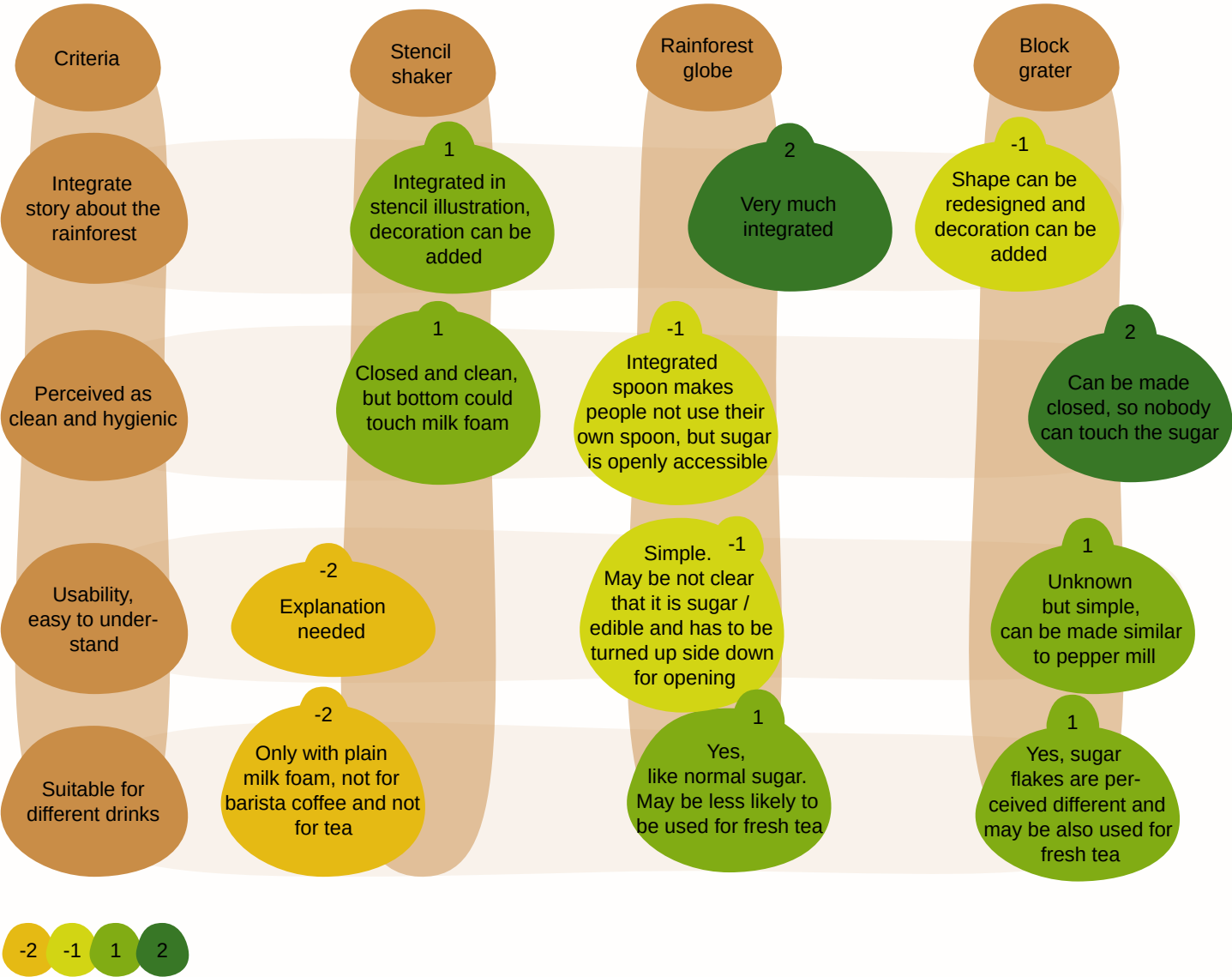


Figure 28: Evaluating concepts based on Harris Profile

Design Detailing

After selecting the concept of the Sugar Block Grater, it is further developed and details are worked out. This is done based on a more specific and targeted vision statement and a programme of requirements (see page 62).

With this, the background story of the Arenga Rainforest Sugar is further integrated in the design, the grating mechanism is developed and the product user interaction is shaped with detailing the design.

Vision

The desired experience is envisioned as described in the following statement in Figure 29. Its elements are further explained on the next pages. It is composed of the vision, the reason for it (why), the design implementation (what), and the way it is experienced (how).



Figure 29: Vision statement

Sweetener

The main function of the product is to be used as sweetener for hot beverages, replacing regular sugar normally offered in a café. Adding the Arenga sugar to the drink should be done consciously, perceived as something special, and enhance the coffee or tea experience.

Story

The sugar's background story should be experienced by the café guests and be subtly integrated in the design of the sugar grater. The people's imagination will be stimulated and curiosity fostered. The important elements of the story are the circularity and balance in the system of the forest community and the rainforest, with its fascinating biodiversity, and the role of the Arenga palm tree supporting it with its sugar.

Need

The design will address human needs. It allows people to live morality and have an impact. The need of morality requires "being able to act on your personal values, passing them on to others, and seeing them reflected in the world" (Desmet & Fokkinga 2018). Having an impact means "seeing that your actions or ideas have an impact on the world and contribute something" (Desmet & Fokkinga 2018). With fulfilling those needs the design should also have an overall effect on the users' experience, attitude and behaviour in the future (Fokkinga, Hekkert, Desmet, Özcan, n.d.).

Emotions

The user (café guest) should experience the emotions of interest, pleasant surprise and virtuousness, while interacting with the sugar product. The pleasant surprise is like for example receiving a birthday card which will unexpectedly reveal a beautiful pop-up peacock when opening it. Virtuousness arises when we have done something that benefited other people or society and comprises enjoying the feeling of being a good or worthy person (Desmet, 2018). The user should feel interest, in particular curiosity, fascination and inspiration, when interacting with the Arenga sugar. More details about the emotions and meanings are explained on page 43 with the product experience.

Meanings

The sugar should be interpreted as special and natural. Special means that the café guests see the sugar as precious, and value it. Natural means that they and understand its natural source and processing, as well as the health benefits. Those two meanings can be conveyed by enhancing on one hand commonalities between natural and special, such as high quality, handmade, unique, and on the other hand not conflicting aspects such as organic shape and detailed, irregular patterns in the product design.

Tool

The tool stores sugar blocks in small reservoir, which can be grated by the café guests into thin sugar flakes. The sugar grater has three different functions: it should be facilitating the meaning of the sugar, be used to serve the sugar, and communicate its background story. The grater should be a decorative element at the café table, possibly replacing a flower vase or candle and serve as conversation starter, encouraging the guests to discover the depicted elements of the Arenga Rainforest Sugar.

Sugar

The sugar blocks should be authentic and special, as traditionally made in Indonesia. The hard and compact blocks will undergo a transformation when being grated to become delicate, light and beautiful sugar flakes.

Metaphor

Grating the sugar is like the opening of a flower bud. Protected by the sepals it is slowly developing, growing, opening, spreading attractive scent and showing its temporary beauty with light, delicate petals, which will be taken by the wind at one point. A flower bud is pure, natural and special. It is offering a positive surprise when it reveals its petals. This metaphor, as guidance and inspiration, expresses how people should interact with the product.

Interaction Qualities

Connected the metaphor of the flower bud, the following interaction qualities should be enhanced: caring, observing and supporting (Figure 30). The product should be treated by the café guests as something precious, valuable and delicate, which they touch and hold in their hand like **caring**, protecting and appreciating. Another aspect of the interaction with the product can be characterised by qualities such as **observing** and discovering, where the user is exploring the product. Furthermore should the interaction have a more active quality, where the user acts as **supportive** and activating. This part also reflects back to the need of having an impact to contribute to something in line with your personal values.

These descriptors of the interaction qualities “represent what users should attribute to the product while experiencing the object and interacting with it” (Hassenzahl, 2004).



Figure 30: Interaction qualities

Product Experience

The product experience can be divided into human-product interactions on the micro, macro and meta level (Özcan, 2016). The different elements as described in the vision are influencing the product experience. They are divided according to the structure of 9 Moments of Product Experience (see Figure 31) to help achieving the desired experience. With the Design Explorations (page 44) and the Final Design (page 64) it is tried to implement these elements in the product design, and tested and confirmed with the User Study (page 78).

The aesthetics on the **micro** level should support the natural meaning and the emotion interest and in particular curiosity. Irregular patterns and interesting textures can foster this curiosity and result in a natural interpretation. The patterns should be visual and tactual. The natural meaning can be supported by organic shapes and natural materials. To further emphasize the curiosity, the sweet smell of the sugar can be collected and guided to reach the user's nose while grating, w

At **macro** level the Arenga sugar should be appraised as special and cause a pleasant surprise with the user. To achieve this, the tool should not look like a regular sugar shaker. It can be a decorative element at the table, where the user does not expect the function in the first place. The sugar flakes will come out as a surprise.

On the **meta** level users can feel interest and fascination. They can interpret the product as authentic, while learning how the forest community forms a sustainable ecosystem with the rainforest. The café guests can support this and will feel virtuousness when realising the impact they can have.

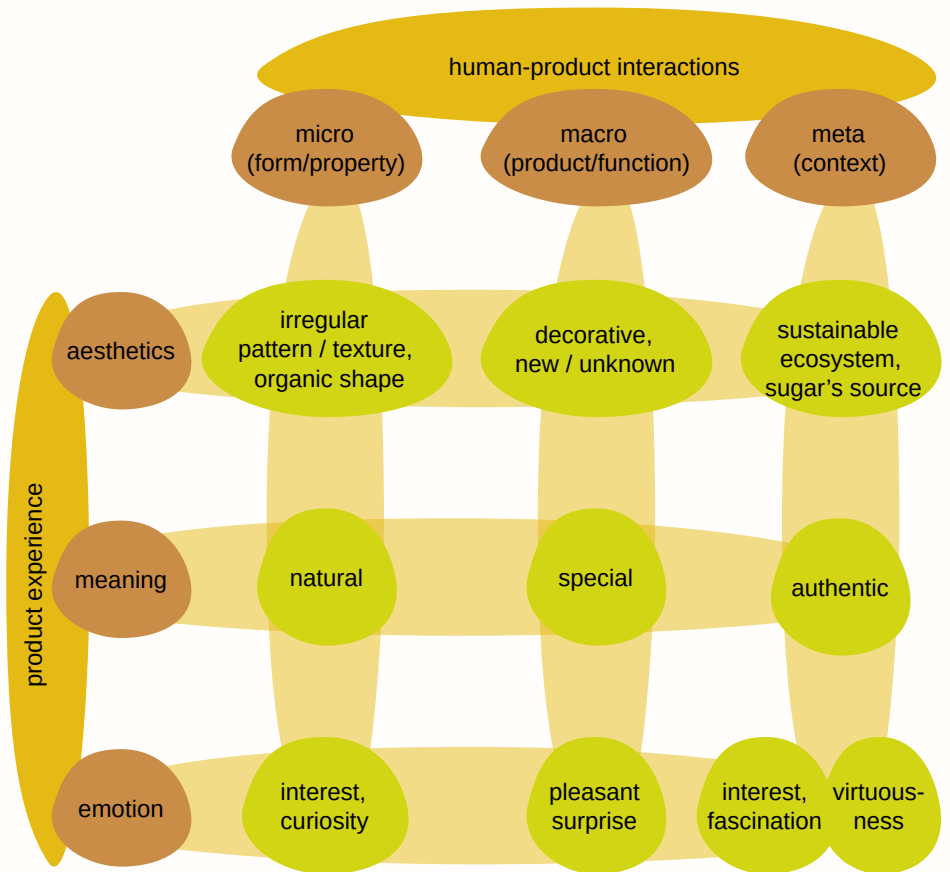


Figure 31: 9 Moments of Product Experience (Özcan, 2016)

Design Explorations

The Sugar Block Grater is further developed based on the vision and design requirements. The shape and properties of the sugar **blocks** and the desired outcome of the shaved sugar **flakes** has to be defined and the details of the grater **tool** are designed. Explorations about those three parts are presented on the next pages, resulting in the programme of requirements, which is then used for the final design.

Sugar Blocks

Traditional sugar blocks are used for the grater. Compared to granulated sugar, the blocks are more simple to produce and give less problems when becoming moist. They therefore not always need to be kept airtight, which is useful for serving in cafés.

The solid form of Arenga sugar is **made** by boiling and stirring the sugar not until it becomes dry granulated sugar, but stop the process a little bit earlier, when the sugar is not yet completely crystallised and the syrup is still slightly liquid, but already very thick. This syrup can be then poured into moulds (see Figure 32), where it cools down and hardens, only partially crystallised. The texture is similar to this of a chocolate bar. The moisture content should be minimised to prevent extra weight for transportation and to ensure the sugar block preserves well and is not sticky, but suitable to shave flakes off it.

Different types of **moulds** can serve to define the block's shape. Traditionally natural materials are used for this. Cocos nut cups or slices of bamboo tubes, which are placed on a wooden plank, can be for example filled with the syrup. There are also moulds carved into or cut out of wooden planks. Round and tapered shapes work well for demoulding, but also cylindrical shapes are fine, because the sugar shrinks when cooling down. The height should be kept relatively small to reduce shrink marks and ensure a more solid block with a relatively straight top surface.

Cylindrical shapes should be produced for the sugar grater, to allow for the sugar flakes to be shaved off the top of the block with a rotational movement (see page 48 for the grater tool mechanism). Several sugar blocks should fit in the reservoir of the grater tool to be able to gradually refill the tool, also already before it is completely empty. It is decided to fit maximal 3 blocks in the tool, resulting in a height per block of ~22mm. The diameter is chosen to be between 43mm and 40mm, to fit the tool and be turned against the knife. This results in a weight of about 42g per block and a total filling weight of 126g, being roughly half of a standard 250g package.

The sugar block's diameter **dimension** has to be relatively precise to work together with the tool. Therefore no bamboo slices should be used, but the circles should be cut out of a plank with the correct thickness and size, considering the shrinkage percentage. The sugar can be roughly poured in the holes and excess can be scraped off. This accelerates the production pro-

cess, as well as this way, demoulding one plank at once is possible.

The sugar blocks **quality** must be checked for among others the pH value, the percentage of inverted sugar and that they are consistently consolidated until the centre of the block. Also the crystallization percentage and hardness must be checked to work well with the knives shaving off the sugar flakes. Palm sugar blocks from an Asian supermarket were used for testing the prototypes and experiment with the flakes. Some of them were though too hard and brittle to grate nice flakes. Further experiments and tests have to be done with the Arenga syrup on-site to be able to produce the right consistency (chocolate like), also considering that the sugar crystals may change over time.

The sugar will be **packaged** in a 250g roll consisting of 6 blocks. Each package is rolled in paper (similar as used for flour, rice or granulated sugar sometimes) and sealed airtight with a circular sticker on the top and bottom, providing more information about the product. The package design will be elaborated later (Consumer brand, page 69). The cylinders can not be packed very space efficiently in a rectangular box. Compared to granulated sugar packages the block sugar is still more compact and can therefore compensate for this slight inefficiency of space during storage and transportation.

The sugar block roll packages will be presented in a special **shelf** in the café, which serves as storage and shop display (see page 59).



Figure 32: Sugar blocks

Sugar Flakes

To present the sugar as something special, emphasize its natural source, and make sure it quickly dissolves in the hot beverage, it should come out of the grater tool as a flower with thin petals. Different tests were done to find a suitable way to grate the sugar blocks. Existing grater tools meant for chocolate, cheese or vegetables were tested, as well as different knives, rasps and slicers.

The sugar flakes have to be cut with continuous rotation with more or less constant speed and pressure, to produce bigger layers, resembling a flower. A suitable thickness was found to be around 1.25mm. If the sugar is shaved much thinner it does not hold its shape long enough and breaks too easily. Same counts for thicker cut-offs becoming not flexible enough to bend, and looking very dark and not dissolving well in the drink. Another requirement for nice flakes are regular consistency of sugar blocks and a flat surface. The sugar block should not be too moist and sticky, but also not too brittle; some syrup is needed to glue the crystals together.

Different tests with the grater prototype showed that the sugar flakes get loose of the knife easily as soon as grating is stopped and then slide well into the cup when the grater is put on an angle.

The sugar flower should look nice and complete with about 4 grams (one regular portion sugar). It could be nice to fine tune the tool in such a way that for example half a rotation would grate 1 gram.

It was decided to make the grater with two knives so that two flakes will spiral around each other, forming a layered look. The top side of the knife should be as such that the flakes smoothly come out of the tool and not get stuck.



Figure 33: Sugar flakes

Tool

For the tool many different ideas were generated and iteratively developed and improved, combining existing products and designing new solutions, making drawings, models and prototypes. Some of the alternatives and considerations are presented in this chapter, regarding the general usage, possible working principles and material and shape options.

The tool (Figure 34) is integrating the design's functionality of grating the sugar and communicating its background story, as well as facilitating the desired user experience. The user should see the sugar flower growing, while grating. The flakes therefore need to come out at the top of the tool, where they need to be collected in a bowl like shape.



Figure 34: Grater tool idea

Usage

The sugar grater is standing on the café's table and grabbed by the guest to grate sugar flakes to sweeten his drink. A rotational motion, similar as with a pepper mill, is necessary to cut the sugar. A handle activating this mechanism, could serve as visual use cue and make this movement more effortless for the user. To observe the sugar flower "growing" and hold the sugar in your hand like something precious with an appreciating gesture, the tool should be grabbed under the upper bowl with one hand, while the other hand is rotating the bottom. An indication of the amount of sugar grated could be given with a mark line inside the bowl, or at the handle indicating the amount of rotations. The sugar collected in the bowl can be then scooped into the cup, by tilting the tool.

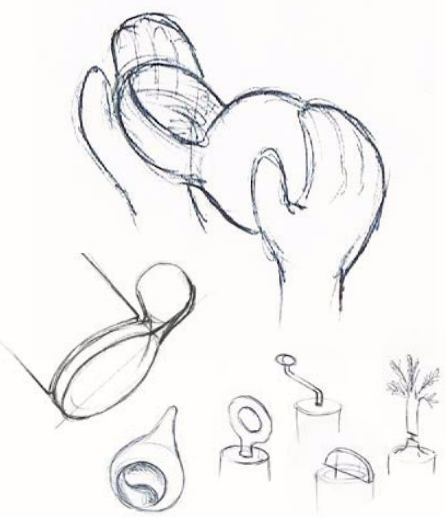


Figure 35: Grating gesture and possible handles

Working Principle

The basic working principle of the grater is that the sugar block and the knife are pushed against and rotated amongst each other, producing two sugar flakes spiralling around each other (see page 46). It has to be decided where the moving connection is and which part moves and which one stays still. Grating the sugar blocks should work smoothly without too much effort. Sharp knives and a well working mechanism where the forces are well distributed are therefore crucial.

Many existing products were analysed, such as pepper mills, cheese graters, nutmeg and truffle slicers, chocolate flakers, vegetable spiral cutters etc., finding useful solutions. For the sugar grater there should however be no central axis, to enable grating one big solid block of sugar, but also several sugar blocks stacked on top of each other. To be able to see the sugar flower coming out of the tool and hold it the way described before, the mechanism has to work against gravity and pushing against or fixing the tool to the table is no option in a café. The sugar blocks have to be kept in a close compartment for hygienic reasons, which has to expand to be filled and then shrink to push the last bit of sugar against the knife. One solution is to have this flexibility internally without changing the outer dimensions of the tool. Alternatively the whole tool can be taller or smaller, depending on the amount of sugar blocks left in the reservoir. This gives an obvious visual indication for the café personnel when to refill the grater, but also has consequences for the aesthetics, requiring a shape which is beautiful and proportional in both extreme scenarios (full and empty).

One possible working principle (see Figure 36) is that the sugar blocks are stacked in a cylindrical container and another part is pushed and rotated on it, with a knife on the bottom, cutting into the sugar. This complete upper part with the knife is pushed inside the sugar container, when the sugar blocks become smaller. This means it has to have a cylindrical shape same length as the depth of the sugar compartment. The sugar compartment has to have a high friction wall with for example some triangular shapes sticking into the sugar from the side and prevent the stacked sugar blocks from turning with the knife. The upper part has a bowl like shape collecting the sugar flakes. This part could be taken out to scoop the sugar flakes in the cup. This would however mean that the sharp knife becomes accessible, as well as the sugar compartment be open. It is therefore better to design the tool in such a way that the two parts always stay connected and can be only opened by the café's personnel for refilling.



Figure 36: Working principle 1

Another possibility (see Figure 37) is to push the sugar against the knife with a (pre-tightened) spring and then rotate it by manually rotating a knob or handle. Pre-tightening could be done with a separate screw knob, similar as used to adjust the fineness with a pepper mill. Another idea was a more playful and surprising design where a wind-up key is used, as known from old toys. This two steps usage could however be complicated to explain to the users. Alternatively the spring could be tightened by continuously rotating, while internally the first rotations are used to tighten the spring and after a certain force is reached it is locked in this position and the tool switches automatically to rotate the sugar blocks and start to cut with the previously built-up pressure. The platform pushing the sugar can be fixed in certain steps and the spring only compensates the distance in between. This can ensure a more constant pressure, not decreasing too much when the sugar block is being used up.



Figure 37: Working principle 2

The sugar can be pushed against the knife by a piston (see Figure 38), which is found to be the most suitable working principle. The pushing force can come directly from the user; it is however difficult to coordinate to push and turn continuously to grate nice flakes. Another solution is using a thread to output the users rotation into a constant pushing force plus rotation. The thread can be like a bolt with a platform pushing the sugar, being screwed through a thread, cut in the bottom of the tool. Otherwise the whole piston can be the "bolt" with external thread, screwing into the top part, which is a tube with internal thread. With this working principle the proportion of rotation and vertical movement is fixed by the thread's pitch. The angle and the cutting depth of the knives could be made adjustable (as found for example with truffle slicers) to handle variety in texture of the sugar blocks and to adjust the sugar flake thickness.

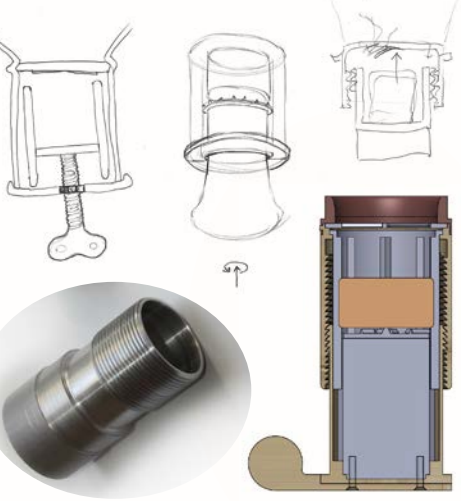


Figure 38: Working principle 3

Material

For the material choice of the tool, it must be considered that the outer part is influencing the product's look and feel and results in a certain meaning and experience for the user. The materials therefore should be matching with the vision and fit the background story of the sugar. The style of the tool should also fit in the interior design of a variety of cafés. From a practical point of view the materials must be hygienic and easy to keep clean, where people touch the tool and where the sugar is in contact with it. Depending on the material choice and suitable manufacturing methods, different shapes are possible (see page 54). This concerns mainly the leaf like bowl, collecting the sugar flakes, but also aspects such as material thickness.

Many different material options were considered such as clay, porcelain, plastic, glass, (woven) bamboo, wood, and different types of metal. The two options of copper and bamboo tube were worked out in more detail. The general design though is compatible with many alternatives and possible to be made of different kind of materials with only slight adaptations.

The internal parts which are in contact with the sugar and not visible for the user can be made of stainless steel and plastic.

The outside of the tool can be made of copper with the inside of the leaf bowl shape being coated with enamel (molten glass glaze) (see Figure 39). The copper has a warm appearance and could change its look over time from for example finger traces, making it visible where to hold the tool. Copper is antibacterial but also has a distinctive smell, which could distract from the sugar's smell. It can be however sealed with transparent varnish. The leaf shape and the cylindrical base can be produced by copper spinning and copper chasing, resulting in interesting textures from the hammering. More texture can be created by engraving or embossing illustrations (see chapter about the story, page 56), which could be interesting to feel and explore with the fingers while holding the tool.

The inner part of the bowl can be covered with enamel, applying either powdered or liquid enamel which then melts with high temperatures in a kiln or with a blow torch. The combination of copper and enamel works well because both materials have the same expansion coefficient. This also means that the material combination can be made dishwasher safe. The enamel creates a hard, sleek surface which is easy to keep clean. The product can have a non-industrial appearance, because each tool will have an individual look, with random enamel patterns, depicting the rainforest in an abstract way with shades of green colour sprinkles. People's imagination may be fostered and they can try to discover animals and plants in the patterns. The green enamel creates a nice contrast behind the brown sugar flakes.

Copper chasing and enamelling are ancient crafts and done by artisan craft-workers, but also possible to gradually scale up to industrial production.

Thin shapes with double curvatures can be made, resulting in an elegant look. The combination of copper and enamel also looks precious, and might be associated with jewellery or a piece of art and will emphasize that the sugar is perceived as something special. Sugar might not be expected in this more decorative object and the café guests could experience a positive surprise. The coppers warm colour and irregular textures from the hammering creates a natural look.



Figure 39: Copper and enamel

The tool can have a coherent look, re-assembling a natural bamboo tube. The bowl and the upper part of the cylinder can be made out of one continuous bamboo pipe. A metal stripe could also stay visible as accent and look like for example chrome, copper, bronze, gold, or green, fitting the café style and for example their cutlery. The bottom part screwing in the sugar compartment can be still made of metal or plastic and be covered with bamboo veneer, resulting in the same look and similar feel. Only the temperature and weight might be surprising for the user. Illustrations at the back of the bowl (palm leaf) and on the cylindrical basis (forest community pattern) could be either burnt, carved or (laser)engraved.

The rainforest inside the grater can be also depicted with more simplistic engravings, same style as the other decorations. This would create a more minimalistic, coherent, neutral and even more natural look, matching with more cafés' style.

surfaces must be smooth and easy to keep

One participant of the user test (see page 78) proposed to cover the internal part with stainless steel, to have a smooth and clean surface. This would however influence the natural appearance of the product and make it more difficult to depict the rainforest inside the “bowl” (see page 56 of food safe resin). A transparent layer of food safe resin to cover the internal part, where the bamboo touches the sugar would be another option and gives it a smooth surface over the engravings. The other bamboo surfaces can be treated with for example food safe mineral oil or linseed oil. No one from the interviewed cafés (Evaluation, page 84) was concerned that the bamboo (with engravings and only treated with oil and no resin applied) may not be clean or food safe. Also a big variety of bamboo products (cutting boards, bowls, serving boards etc.) are sold in professional gastronomy shops.

design with bamboo.



Shape

The tool's shape should be aesthetically appealing and have balanced proportions, both in the full and empty state (height difference around 66mm). The basis of the tool must fit the cylindrical sugar blocks and house the rotating and cutting mechanism and give use cues about how to handle the tool. The width of the cylindrical base must fit comfortably in people's hands. If the diameter is between 50mm and 65mm it fits both P5 (108mm grip circumference) and P95 (150mm grip circumference) of Dutch adults (Dined, 2004). The upper part holding the sugar flakes must be shaped such that the user does not touch the inner surface with his fingers, but keep the inner part touching the sugar clean. This requires a rather closed shape, which still should not be too deep, so that the sugar flakes are directly visible and easy to get out. This bowl part should also give visual hints about the sugar's background story (see next page) and depict the shape of an Arenga palm leaf.

Many different shapes were developed with drawings, CAD models, 3d prints, clay models and other simple models made of for example paper rolls (see Figure 41). See page 60 for more details about the prototyping. Extreme shapes were explored from very simple tubes to double curved and perfectly fitting the user's hand with separate indents for the fingers. Those might not be compatible with varying hand sizes and right and left-handed users, but give a clear hint about the intended holding gesture, where the tool should be grabbed under the upper bowl with one hand, while the other hand is turning the bottom such that the user can observe the sugar flower "growing", while holding it in the hand like something precious with an appreciating gesture. The back of the bowl should therefore feel interesting and good to touch with a smooth surface. The natural appearance of the tool can be supported by an asymmetric, irregular shape, referring to a leaf or tree. The shape can look delicate and special. A sharp point could support this elegant look, but may be dangerous and risky to break. The geometry of the bowl should be also rather closed to be stable and stiff, making it possible to have a robust resin or enamel coating which would not break off.

Double curvature shapes and potentially varying material thickness may not be compatible with the material choice and connected production methods. If the bowl shape is made of clay both would be possible. With copper chasing double curved shapes are possible and even more complex indents can be made with a die. With bamboo complex shapes could be made by weaving bamboo stripes which then could be stiffen with resin. Otherwise three steam bent slats could be glued to an interesting shape (similar to top left of Figure 41). Simpler to make and referring more to the typical bamboo tube look would be a basic pipe cut under an angle. This cut can be either straight or with a curve. This results in a rather minimalistic design, allowing for more decorations without making the design look too complex.



Figure 41: Shape explorations

Story

The sugar's background story should be experienced by the café guests and be subtly integrated in the design of the sugar grater. The people's imagination will be stimulated and curiosity fostered by discovering the metaphorical elements in the design, which are further elaborated on a website and printed information material. The important parts of the story are the circularity and balance in the system of the forest community and the rainforest, with its fascinating biodiversity and the role of the Arenga palm tree supporting it.

System

The farmers living in the rainforest benefit from the nature in the same way, as the biodiversity benefits from them, since the forest community has an intrinsic motivation to protect it. The design should show the harmony in this system and how all parts are integrated and important. The café guests can be the driving force to keep this circular system running.

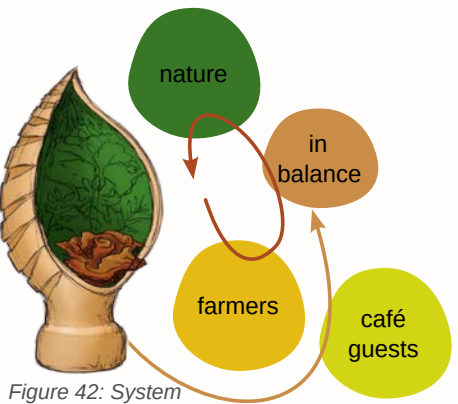


Figure 42: System

Rainforest

The rainforest is represented inside the bowl. Random sprinkles of shades of green create unique patterns representing the rainforest together with abstract natural elements showing the rich biodiversity and offer many details for the café guests to discover. Different levels of abstraction are possible and alternatively also a more realistic drawing could be used. The rainforest is like a small world, supported by the forest community and protected by the Arenga palm tree, which “puts its leaves and roots around the forest”. The sugar grows inside the rainforest, same as the sugar flower is growing in this bowl, when the user operates the grater.



Figure 43: Rainforest

Arenga Palm

The Arenga palm tree is depicted outside at the back of the bowl with a palm leaf, which can be also used as logo. Its roots transition into a traditional Dayak tribal pattern. The tree is “rooted” in the forest community, showing its connection and how they both benefit from each other, the people protecting the rainforest and the tree providing them with sugar. The tree's deep roots play an important role for the biodiversity, stabilizing the forest soil and also supporting reforestation. The Arenga palm is a wonder tree, naturally growing in the Indonesian rainforest and providing the forest communities with valuable resources, such as the Arenga sugar.

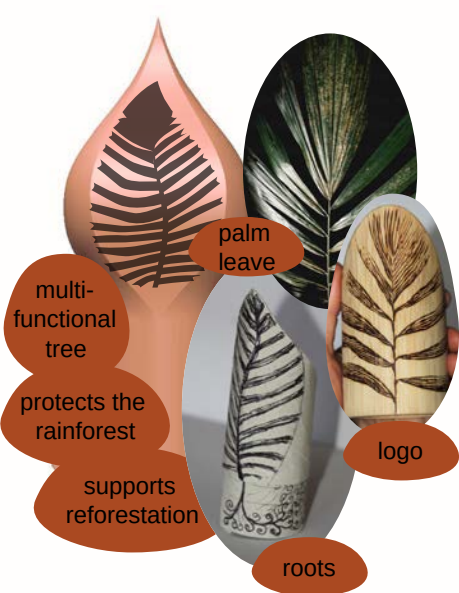


Figure 44: Arenga palm tree

Sugar

The Arenga sugar is growing in the rainforest, as the user also experiences with the tool. The sugar creates economic value for the forest community and provides them with an income, but also for the café guest it is presented as something special and valuable, by growing like a flower. This image emphasizes the sugar's naturalness, being unprocessed and healthy. The sugar sap is traditionally collected in bamboo tubes, which is also visible in the tools design, made of bamboo.



Figure 45: Arenga rainforest sugar

Forest Community

The forest community is represented by a stripe of tribal patterns at the bottom of the cylindrical base and the knife and the processing part of the tool. The local people are sustainably wild-harvesting the Arenga sugar, by cutting the flower stalk to tap the sugar sap, like the knife is cutting the sugar in the grater tool. They are traditionally living in harmony with forest and value and protect nature.



Figure 46: Forest community and processing

Café Guests

The café guests become part of the story by supporting the sustainable system of rainforest, forest community and Arenga palms through consuming the Arenga sugar. The image of being the “driving force” for the system is supported by the active gesture of turning the base with the right hand using the handle, to grate the sugar flakes. The other part of the user is more supportive and appreciating by holding the sugar flakes in the bowl in the left hand.



Figure 47: Café guests

Website

The café guests can scan a QR code at the bottom of the sugar grater, which links to *forestwise's* website (Figure 48). The landing page gives an overview of the different elements of the story (as described at page 56), with clear references to the product design, making it easy for people to recognise the metaphorical elements.

When clicking on the rainforest part, a screen filling green image of the abstract rainforest appears, looking similar to the one on the tool. The user can zoom in the image and scroll around to discover the biodiversity of the rainforest. By zooming in, more detailed and realistic images of plants and animals appear. Clicking on them opens a pop-up with a short explanation. Zooming out brings him back to the overview. The Arenga tree, the sugar and the forest community can be explored in a similar way.

The website should be optimised for smartphones and easy to use on small screens.

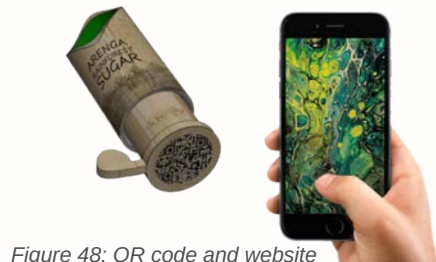


Figure 48: QR code and website

Consumer Brand

Forestwise plans to launch a consumer brand for the Arenga Rainforest Sugar. Currently they are just selling crystallised sugar in bulk to other businesses. *Forestwise* can start to approach the consumer market with 250g pouch bags of granulated sugar, and 250g rolls of block sugar, as well as the grater tool for home use. First a convenient channel would be to sell the products in cafés, using the trend of blurring, where cafés and shops are merging (see page 8, Market trends). Later also delicatessen and ecological shops etc. can be approached.

The brand is visible to the end consumer with a specially designed shelf (see next page), the packaging, the grater tool at café tables, and possibly extra information on the website.



Figure 49: Packaging and logo design

The **packaging** design should fit the vision and desired image of *Forestwise*, conveying a natural, authentic and sustainable image. Other Arenga sugar packagings were analysed (see page 10, Benchmarking) to design the Arenga Rainforest Sugar packaging. Robust brown paper bags and rolls should be used to pack the sugar, air-tightly sealed with stickers. A minimalistic illustration of the Arenga leaf should be used as logo, which can be printed or stamped on the packaging. This also refers to the Arenga leaf at the back of the sugar grater tool, creating a coherent and recognisable brand image.

Extras

To support the consumer brand and complete the design and offer a coherent concept to cafés there could be also more extras designed. A shelf design supports the Arenga sugar products' presentation, but also more table decorations as for example coasters could be added to the range. Furthermore informative posters, info blocks for in the menu and social media content could provide the café guests with more background knowledge about the Arenga rainforest sugar. A poster in the window or on top of the bar could also tell guests that this place sells Arenga Rainforest Sugar. A few designs are suggested here, but more can be developed and also existing products can be integrated in the assortment, to offer a whole interior concept to newly opening cafés, consisting of furniture, decoration (plants, pots, candle holders, vase etc.) and condiment trays, menu stands, as well as salt and pepper etc. By choosing mainly bamboo a coherent image can be created. Tropical plants and botanical illustrations would go well with it. In general it should be also paid attention to choose sustainable options.



Figure 50: Extras (existing designs, fitting the concept)

Shelf

A shelf design is proposed which serves as storage of the sugar blocks in the café, as well as a product display in case the café is also selling the rainforest products (sugar blocks, granulated sugar, grater tool). The shelf consists of individual boxes made of bamboo, which can be arranged in a flexible way and different sizes. The modular box system can be hung in different constellations on a wall or stacked on the floor, a table or for example the side of the bar. A variety of high quality nature photographs of rainforest animals and plants in the back of each box create a nice contrast and context to display the sugar packages. The style of the shelf should match the grater design and the website. It could be also considered to print drawings at the back of the shelf or directly engrave into the bamboo. When the storage is (almost) empty the boxes just look like picture frames.

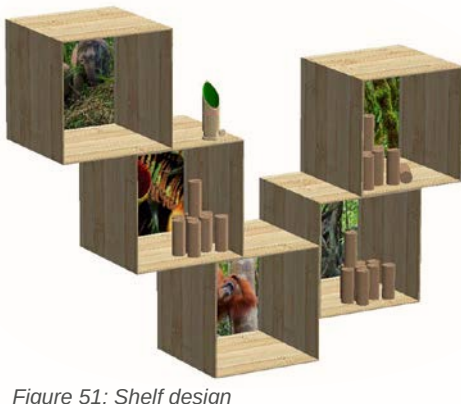


Figure 51: Shelf design

Coasters

Coasters could be made in a very similar way to the grater tool and use rests of the bamboo tubes. Thin bamboo rings can be cut and filled with resin with integrated real leaves, moss, or printed and cut out objects, combined with pigments and colour drops, matching the design with the green resin rainforest. Alternatively also more minimalistic drawings similar to the engravings could be covered by resin. Also photos are possible to incorporate in the resin coasters. *Forestwise's* logo, extra information or the cafés name can be laser engraved at the bottom of the slices.



Figure 52: Coasters made of bamboo and resin

Programme of Requirements

This list of requirements states the important characteristics that the design must meet in order to be successful. Those requirements apply for the sugar and for the tool, which used to grate it and convey the basic story, as well as for the website with additional information.

The requirements are based on the initial design criteria drafted before the idea generation in the chapter Synthesis (page 22). After choosing the concept of the sugar block grater and further developing, prototyping and testing it more specific requirements were drafted. A process tree was used to define criteria for product development, while considering the whole product life cycle, from originate, distribute, use to discard (Boeijen, Daalhuizen, Schoor, & Zijlstra, 2014, p. 67). Those criteria were then sorted according to Pugh's checklist to make sure the Programme of Requirements is complete (Boeijen, Daalhuizen, Schoor, & Zijlstra, 2014, p. 103). This list fits the current state of development. It serves as starting point for further development, where it should be used as guideline, but also checked and updated when gaining more insights from for example user tests.

The demands (D:) must be met and wishes (W:) should be achieved as much as possible.

Performance

Sugar:

D: The main function of the Arenga sugar is to sweeten coffee and tea, the flake thickness must be such that the sugar dissolves within under 10 seconds stirring in hot beverages

W: Arenga sugar might replace regular sugar and honey in cafés

Grater tool:

D: The grater must smoothly cut the sugar blocks into flakes

D: The tool must be able to turn several sugar blocks stacked against the knife

D: One portion of sugar (4 grams) must be grated with maximal 5 rotations.

W: One rotation should give predefined amount of sugar (for example 2g)

D: The tool must function from full to empty

W: The tool design should make people curious about the background story of the Arenga sugar and provide them with first information and help them with where to find more information (QR code)

Website:

D: The website must provide more updated information about the sugar's source and impact and tell people ways to support

W: The website should be inspiring and invite people to explore

Environment

D: The sugar must be in a closed compartment in the tool so people cannot touch it

D: The sugar and tool must be perceived by café guests as clean and hygienic

Life in Service

D: The grater tool must withstand daily usage by roughly 5 users per day over the duration of minimal 3 years, as well as weekly cleaning

W: Life in service time should be possible to extend by regular cleaning and maintaining, repairing and refurbishing

Maintenance

D: The tool must withstand cleaning (hand washing with brush and detergent)

D: The tool must be easy to refill, also possible when it is not yet completely empty

D: The knife slice must be replaceable with basic tools

End of life

D: The tool must be possible to maintain or upgrade (wear and tear, fashion, cleanliness), the parts of the tool must be possible to replace separately

D: The materials must be possible to separate for recycling

Target Product Cost

D: The target cost for the tool should be 15€ and 1€/250g sugar blocks

W: The sugar and tool maybe sold at a premium price (minimal 30€ for the grater and 3€ for sugar blocks) to target the high quality market

Product Life Span

D: The product (with small updates and changes) should be produced and sold over the period of 5 to 10 years

Quantity / Series Size

D: The production should start with pilot of 50 products which can be tested and then produce a small batch of 500 pieces in the first year

W: The design must be possible to easily upscale in the future

Production

D: The production of the sugar and the tool should take place in Indonesia to locally create work

D: Clear instructions for production must be provided

D The quality must be regularly checked

D: The production methods must be scalable

Packaging

D: For the tool and the sugar minimal packaging should be used made from natural material or paper, which is recyclable or biodegradable

D: The packaging must be compact and lightweight

D: The sugar packaging must be airtight closed, visually attractive and informative, to use to display in café shops

Transportation

D: Tools and sugar packages must be compact (shape and packaging) to efficiently ship them by container

Size and Weight

Sugar

D: The cylindrical sugar blocks must have a diameter between 43mm and 40mm to fit the tool and be turned against the knife

Tool

D: The tool should be able to hold minimal 100g of sugar blocks (refill once per week)

W: The tool should be small to nicely fit on café table and stand stable

Aesthetics

D: The tool must look natural and special

W: The tool should be aesthetically appealing and serve as a decorative element on the table

W: The tool should match many cafés' style

Materials

D: The materials used must have a natural look and feel

D: The materials must be sustainably sourced

Ergonomics

D: Café guests must be able to understand that it is sugar to be used to sweeten coffee and tea and how to use the product and get some hints of the story (cognitive ergonomics)

D: The tool must be possible to be comfortably used by P5 to P95 of Dutch adults (anthropometrics). It must be held in one hand (diameter tool between 50 and 65mm), easy to lift (weight total sugar and tool not more than 500g) and grate easily (force needed to grate the sugar must not exceed 10N)

Storage

W: Cafés should store all the refill sugar blocks as a visible, decorative element

D: Replacement parts for the tool must be stored in the Netherlands

Installation and initiation of Use

D: Basic assembly of the top part (leaf bowl) and the basis will be done at the café before the first usage as well as filling the grater with sugar blocks

D: Usage should be simple and intuitive so no learning time is required

W: The personnel could be provided with basic information to tell guests about the Arenga sugar

Standards, Rules and Regulations

D: The sugar and the tool have to comply with food safety regulations applicable in the Netherlands and other relevant product import norms (for example CE)

Safety

D: There must be no risk to cut fingers (for guests and when refilling) and the tool has to comply with General Product Safety Directive 2001/95/EU.

Product Policy

D: The product should be produced responsibly with a fair wage to all workers and with minimal environmental impact

Societal and Political Implications

D: The complete design should create awareness about the importance of the rainforest and promote sustainably wild-harvested forest products

W: Profit should be used for reforestation and sustainable investments

Final Design

In this chapter the final design is presented, forming the outcome of this graduation project. The design consists of the physical grater with its mechanism, transforming the sugar blocks into sugar flake flowers. The tool lets coffee bar guests experience the Arenga Rainforest Sugar's story. The different parts of the design are explained in detail in this chapter and evaluated in the next chapter.

Usage

The tool to serve the Arenga Rainforest Sugar in coffee bars is used by café guests to grate traditional hard sugar blocks into beautiful sugar flakes, to sweeten their hot drinks, such as coffee and tea. The context of use for the sugar grater are cafés in the Netherlands. The focus lies on small speciality coffee bars with hip guests, offering a range of tasty, healthy and sustainable products with a transparent story (see "Product Context" on page 8, "Target Group" on page 26 and Evaluation context on page 84). It enhances the experience of the Arenga Rainforest Sugar and facilitates a new way of serving sugar.

A scenario (Figure 54) of the usage of the product gives an overview of the design in a similar way as a user would discover the Arenga Rainforest Sugar grater in a café. The guests first enter the café, sit down, check the menu and order at the waiter. The first interaction with the Arenga Rainforest Sugar could be either discovering the extra flyer or the info box about the sugar in the menu or realising the grater standing on the table, which looks interesting, natural and special.

When the drink is served, the guest might look for sugar to add. The word "SUGAR", engraved at the front of the tool on the table should give a hint, but the whole product might be unknown and surprising for the user. Grabbing the grater and reading the whole text "Arenga Rainforest Sugar" and looking at the other engraved illustrations gives an idea about the source of this special sugar. The grater feels a bit heavy and the engravings are interesting to touch with the fingertips. Looking inside the top of the grater, small sugar flakes on the knives are visible and the nice smell might be noticed.

The cylindrical shape, the parting line between the bamboo and the metal base, and the handle give the user the hint to use the tool similar to a pepper mill. Starting to turn the base and looking inside the top, it is visible how the sugar flakes come out there, growing and looking like a flower. One rotation grates around 2 grams of sugar and two rotations results in a nice sugar flower with several layers of petals. The caramel flavour of the sugar can be smelled and the sugar's appearance should be a pleasant surprise for the user.

To add the sugar then to the drink the user tilts the grater and lets the sugar flower slide into the cup. The flakes shortly float on top of the milk foam and then slowly dissolve and sink. After stirring the drink, the user tastes and checks if the drink is sweet enough. The whole experience with the sugar stimulates interest and fascination with the user.

While enjoying the drink the café guest looks again at the illustrations on the grater and maybe reads extra informations with the menu. When using the grater before, the guest also noticed the QR code at the bottom of the tool, which he scans now with his phone to check-out the website. Understanding the deeper meaning of the product and the background and impact of the Arenga Rainforest Sugar creates a good feeling about contributing to it.



Figure 54: Scenario



The user experiences the Arenga Rainforest sugar as something special with this grater design. It facilitates a new way of serving this sugar with many metaphorical layers and subtleties with aesthetics, emotions and meanings, as aimed for with the vision statement (page 40).

The guests are stimulated to be active and are supported to create something themselves (the sugar flower), which should make them more aware of the sugar, treat it consciously and see it as something valuable. The big (not compact) sugar flakes in the shape of a fragile flower support this association with something precious. Furthermore, the user can observe the sugar flower “growing” while holding the sugar in his hand with an appreciating gesture (see “Interaction Qualities” on page 42).

Not only the flower shape and colour of the sugar, but also the look and feel of grater support the natural appearance of the sugar.

The flakes are shaved off traditional sugar blocks, supporting the authentic image. This special shape and texture of the Arenga sugar help to differentiate it from regular brown sugar and makes its unique story more clear for the user.

For more details regarding the sugar blocks and flakes used in the final design see the description with the design explorations (page 44 and page 46).

The Arenga Rainforest Sugar should be experienced as natural, special and authentic with emotions such as curiosity, pleasant surprise, fascination and virtuousness. The message of a healthy, sustainable and transparent product should be also conveyed by the grater and its usage.



Figure 55: Tool design

Outside

The outside of the grater has a coherent look and feel with an integrated shape. The bamboo dominates the tool's appearance with engravings as decoration and some shiny metal as accent.

Bamboo tube

One bamboo tube covers the upper part of the mechanism and forms a scoop on top of the tool (see Figure 55). The material choice of bamboo is in line with the natural experience of the sugar and supports the sugar's story, since the farmers also use bamboo tubes to collect the sugar sap from the Arenga trees. For more reasons for the material selection of bamboo see page 53.

The part can be made of a dried, continuous bamboo tube, having roughly the right measurements (inner diameter maximal 52mm and outer diameter minimal 60mm). The tube is cut under an angle and both sides can be used, reducing waste material. In case there are cracks in the material, they should be broken and glued (with food grade glue) before sanding the surfaces smooth according to the measurements. Inside a step is created, making the bottom of the tube wider to slide over the mechanism (see “Assembly” on page 71). The bamboo is treated with odourless, food grade oil.

Decoration

Decorations on the bamboo complete the look of the tool and communicate the sugar's background story to the café guest (see more about the “Story” on page 74)

The text “ARENGA RAINFOREST SUGAR” is engraved in capital letters on a spiral line around the grater. The most important message “SUGAR” is shown on the front, just underneath where the sugar flower comes out. The line however begins at the top back of the grater, saying “ARENGA”, as explanation above the Arenga palm leaf logo. Following the line the word “RAINFOREST” appears from an angle where the rainforest illustration is visible inside the tube. Following the line down and passing the “SUGAR” text, illustrations show where the sugar comes from. The process is illustrated from rainforest and Arenga palm tree, harvesting the sap, boiling it, and moulding it in cylindrical blocks. Following the line all the way down leads to the handle at the bottom, which continues the spiral with its rotation around the base and depicts a finger print to show the user's role. At the bottom a QR code is engraved.



Figure 56: Engraved decorations

The engraved illustrations and text can be carved or burnt in the bamboo. Manual carving or pyrography is though very time consuming. A heated metal stamp could burn the engravings in the bamboo. Otherwise a 4 axis cylinder CNC engraving machine with laser or other cutting or burning tools could be used. This would also allow for adapting the decorations according to cafés' branding. A high enough contrast should be created for good readability. From further away it looks though nice if the decorations are more subtle.



Mechanism

The grating mechanism (see Figure 57) is explained in this chapter with all its parts. It consists of one cylinder with external and one with internal thread, a knife, a ring, a sugar holder, a piston with an extra pushing plate and a handle. How those parts are assembled is also presented in this chapter.

The basic working principle is that the sugar blocks are stacked inside the grater and pushed and rotated against the knife, shaving off the sugar flakes. In Figure 57 only one sugar block is shown, but up to 3 sugar blocks can be stacked on top of each other. In this case, when the grater is just refilled, is the bottom part almost screwed out completely. When the base is rotated (with the handle) it screws into the upper part. The piston pushes the sugar upwards with the metal plate with spikes sticking in the bottom sugar block, transmitting the rotation to the sugar. The piston also rotates the sugar holder, to ensure that the upper sugar blocks also rotate. They are clamped in the sugar holder, which has triangular profiles at the inner wall to create high friction against rotational motion and turn all sugar blocks together. The sugar holder is though very smooth in the vertical direction, to ensure that the sugar blocks can be easily pushed upwards. The sugar holder also encloses all the sugar blocks and makes sure that they do not get in contact with the thread, keeping the mechanism clean and well working. The sugar holder rotates on top of the upper cylinder on a small rim, which holds the

sugar holder in place. When the base is further screwed in, the sugar holder slides further in the gap between the piston and the cylinder with external thread.

The mechanism is kept simple with a minimum amount of parts, to ensure easy (dis-) assembling.

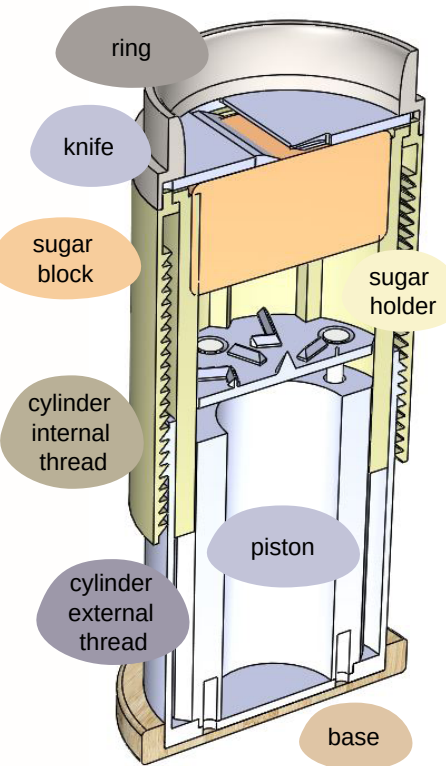


Figure 57: Parts of the grating mechanism

Threaded Cylinders

The two cylinders have a right-hand thread, which is intuitive for most users. The external and internal thread should screw smoothly to transmit the rotation and vertical force from the user with as little friction as possible. A buttress thread, where the load-bearing thread face is perpendicular to the screw axis, is suitable because shear forces are prevented. It can be easily machined on a lathe with a buttress thread tool.

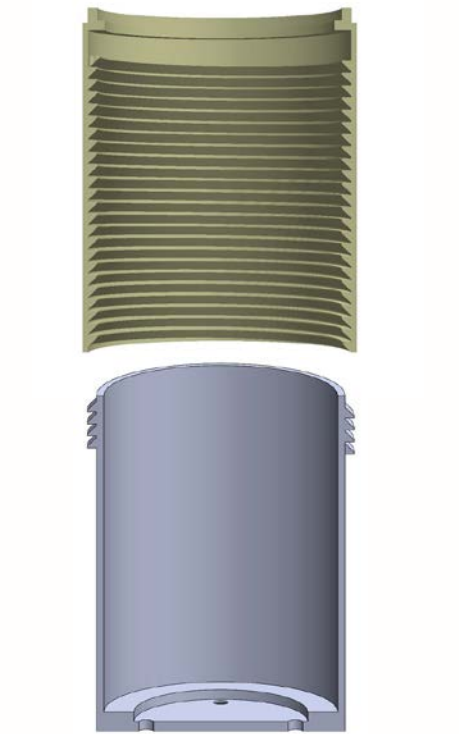


Figure 58: Section view of thread internal (top) and thread external (bottom)

The two parts of the thread should be made out of two different materials, ideally one metal and one self-lubricating plastic. The bottom part with the external cylinder is made from metal (preferably stainless steel or alternatively brass) to have a low centre of gravity and ensure stable standing of the grater. The upper part with the internal thread can be made of POM, nylon or for example iglide® (from igus.com), a self-lubricating food-safe, high-performance polymer. A thin metal sheet should be placed on the top rim of this plastic part to create a good bearing with the sugar holder, rotating on there.

The thread's pitch has to be in accordance with the flake thickness and the angle and cutting depth of the knife. A pitch of 2.5mm was found to be slightly too much, although other factors have to be tested first before being able to draw a final conclusion.

The external thread should be as short as possible to have it not visible when the grater has its maximum expansion and being just refilled with 3 new sugar blocks. On the other hand, it must be long enough to overlap when screwed completely in the internal thread, when the last sugar block is about to be used up. The internal thread however can not go all the way up because the thread cutting tool needs some free run on top before the rim, which can be however minimal with a computer controlled lathe.

Knife

The circular knife is made out of one piece of stainless steel. The two blades are die-cut, bent downwards and afterwards hardened and sharpened. The part has to be stiff and strong enough to withstand the pressure of the sugar block, with the blades going all the way to the centre. The blades are facing downwards and sticking in the sugar block and therefore safe and not possible to touch for the user. The top surface of the knife slice is flat and allows the sugar flakes to smoothly come out of the grater without getting stuck or breaking. The optimum angle and cutting depth for the blades should be still tested. With a pitch of 2.5mm it was expected that each blade should stick out 1.25mm, but this could not be confirmed yet.



Figure 59: Knife

Ring

A metal ring finishes off the mechanism on top and holds the knife slice in place. It is fixed to the upper cylinder with a bayonet quick closure, an L-shaped cut-out, which can be pushed and rotated over a pin. The bamboo tube is being slid over this ring and also held in place by it. The ring has a rounded edge towards the inside (with an asymmetric fillet) to create a smooth transition between the ring and the bamboo, where the sugar flakes can slide over. The ring should be made of stainless steel to have the same appearance as the bottom cylinder with the external thread, to create a coherent look, when they are both visible.



Figure 60: Ring

Sugar Holder

The sugar holder encapsulates the blocks and rotates them. It is a cylindrical shape with triangular profiles sticking inwards, but not going all the way up, because otherwise they would be cut by the knives. The rim on top has to have a smooth surface and as little friction as possible to rotate on the upper cylinder.

This part might be a bit challenging to produce on a small scale. In the beginning 3D printing could be suitable, although smooth surface properties are required for the mechanism to work well. When the product is upscaled, injection moulding might be considered, possibly starting with a low investment 3D printed mould. Alternatively would be aluminium extrusion an option with some postprocessing turning and then a food grade surface treatment.

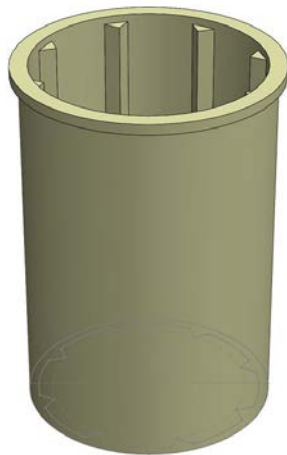


Figure 61: Sugar holder

Piston

In the centre of the mechanism and fixed to the lower base of the grater is the piston, which pushes the sugar against the knife. It can be milled out of a thick pipe since it has a hollow centre to reduce material and weight. On the outside it has triangular grooves to transmit the rotation to the sugar holder and allow it to slide inside the holder and push the sugar blocks all the way through. The piston has to be as long as the 3 sugar blocks together to compensate and push the sugar when the grater is full, as well as when it is almost empty. On top of the piston is a slice which is flexibly fixed on pins and with springs around to prevent the mechanism from getting stuck, but allow the knives to cut around hard parts in the sugar. On the slice are small thorns which are punched and bent up to stick in the sugar block. Extra distance keeper at the sides next to the blades ensure that the thorns do not damage the knife.



Figure 62: Piston

Handle

The handle at the base of the grater enables the user to rotate continuously with one or more fingers, without having to change the hand position about each half turn. The extra arm of the handle increases the user's finger force. The handle has an indent and engraved index finger print to show which direction to turn. It is carved out of one piece of laminated glued bamboo. It is decided to add the handle to the mechanism, because people can still not use it if they prefer, but it makes the usage more clear and also dedicates a special part of the design to the user, representing the impact of the café guest by making the "system turn" (see more with the "Story" on page 74).



Figure 63: Handle

Assembly

The grater consists of two sub-assemblies, screwed into each other. In the bottom assembly, the cylinder with external thread is connected to the bamboo handle and the piston inside with bolts. The sugar holder is illustrated in Figure 64 (left) with the bottom assembly, because those parts rotate together. The sugar holder is connected to the top cylinder and only slides into the bottom. When assembling the upper part, the sugar holder is inserted from the top, where it sits on a rim of the upper cylinder. This is the bearing where the two assemblies rotate. The knife is then placed on the top of the upper cylinder and clamped in place with the ring, prevented from rotating by two pins. The knife is easy to replace if it becomes blunt. The whole upper assembly is slid into the bamboo tube. Some grooves in the ring prevent the bamboo from turning. All connections between parts are made against the grating direction, to ensure the tool does not accidentally fall apart while the café guest is using it.

First assembly requires that all parts are clean and that no dangerous residues of lubricants and oils or dust can end up in the food. How the (dis-) assembly works in practice is further elaborated on page 72, where it is explained how the café personnel can refill and clean the grater.

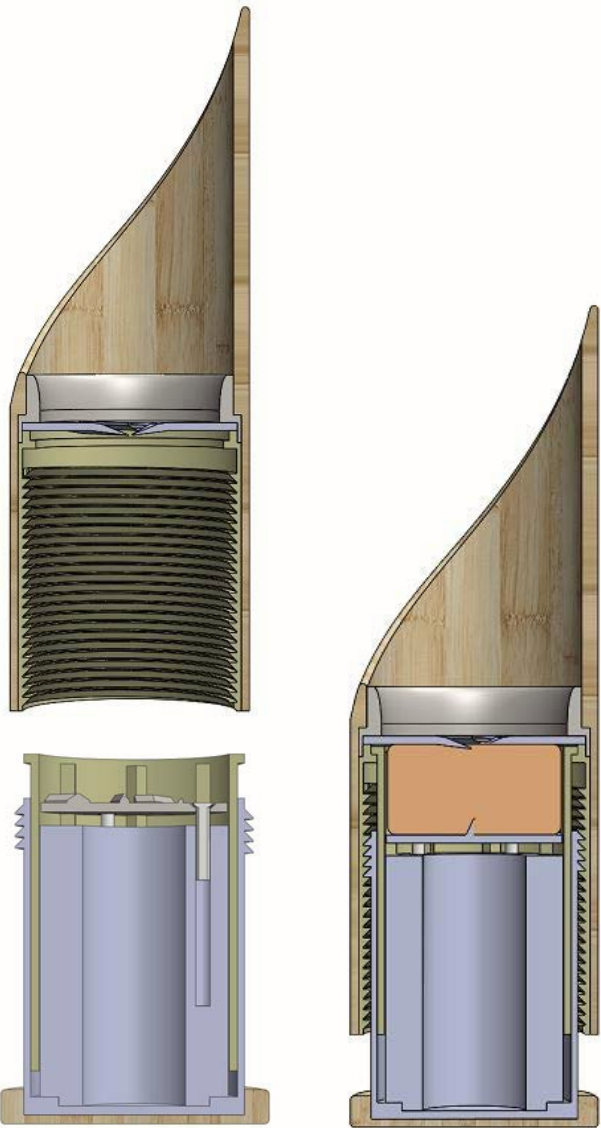


Figure 64: Assembly

Usage for Personnel

The grater can be easily refilled and cleaned by the personnel of the café.

Refilling

The grater adapts its height to the amount of sugar blocks inside. The overall height and how much of the stainless steel is visible at the base of the tool give clear feedback to the personnel about the filling state of each grater. Quickly looking at all tables is sufficient to determine which graters need to be refilled (see Figure 65).

It is possible to refill the sugar blocks already before it is completely empty, without creating waste. This allows for smoother work-flows and regular procedures for refilling all graters. The grater can be filled with around 125g of sugar, resulting in more than 30 portions of 4g.

To open the tool, the base can be completely screwed out, in the opposite direction as grating. The old sugar block stays on top inside the sugar holder, pressed against the knife. This left-over sugar will be used up first after refilling, guaranteeing continuous material flow, where no bits of sugar remain in the grater for too long. This allows that all sugar will be used without waste. Only the little bits stuck between the thorns at the piston slice may require removal.

New sugar blocks can be pushed inside the sugar holder from the bottom. The triangular profiles on the sugar holder cut in the side of the sugar blocks to rotate them while grating. The sugar holder can be filled almost completely, leaving a few millimetres free at the bottom (depending on the material choice of the sugar holder and piston to transmit the rotation). The tool can then be closed again by screwing the base in the top. After a few rotations the bottom of the sugar holder slides into its gap in the base and starts being rotated. The grater is now ready for use.



Figure 65: Refilling

Cleaning

The grater should be cleaned regularly. It has to be opened and all leftover sugar collected. This can be reused to refill the graters afterwards or serve as ingredient for cakes or other recipes. It is safe to reuse this sugar, as guests are not able to touch the it inside the grater.

It is possible to disassemble all parts for cleaning. The two bamboo parts can be separated from the mechanism by sliding off the tube towards the top and unscrewing the handle. The bamboo should be washed by hand with warm water, soap and brush with food-safe oil about once per month. All other parts of the mechanism can be disassembled by removing the ring. The metal and plastic parts are dishwasher-safe.

After drying, all parts can be assembled again and the grater can be refilled with sugar and closed.

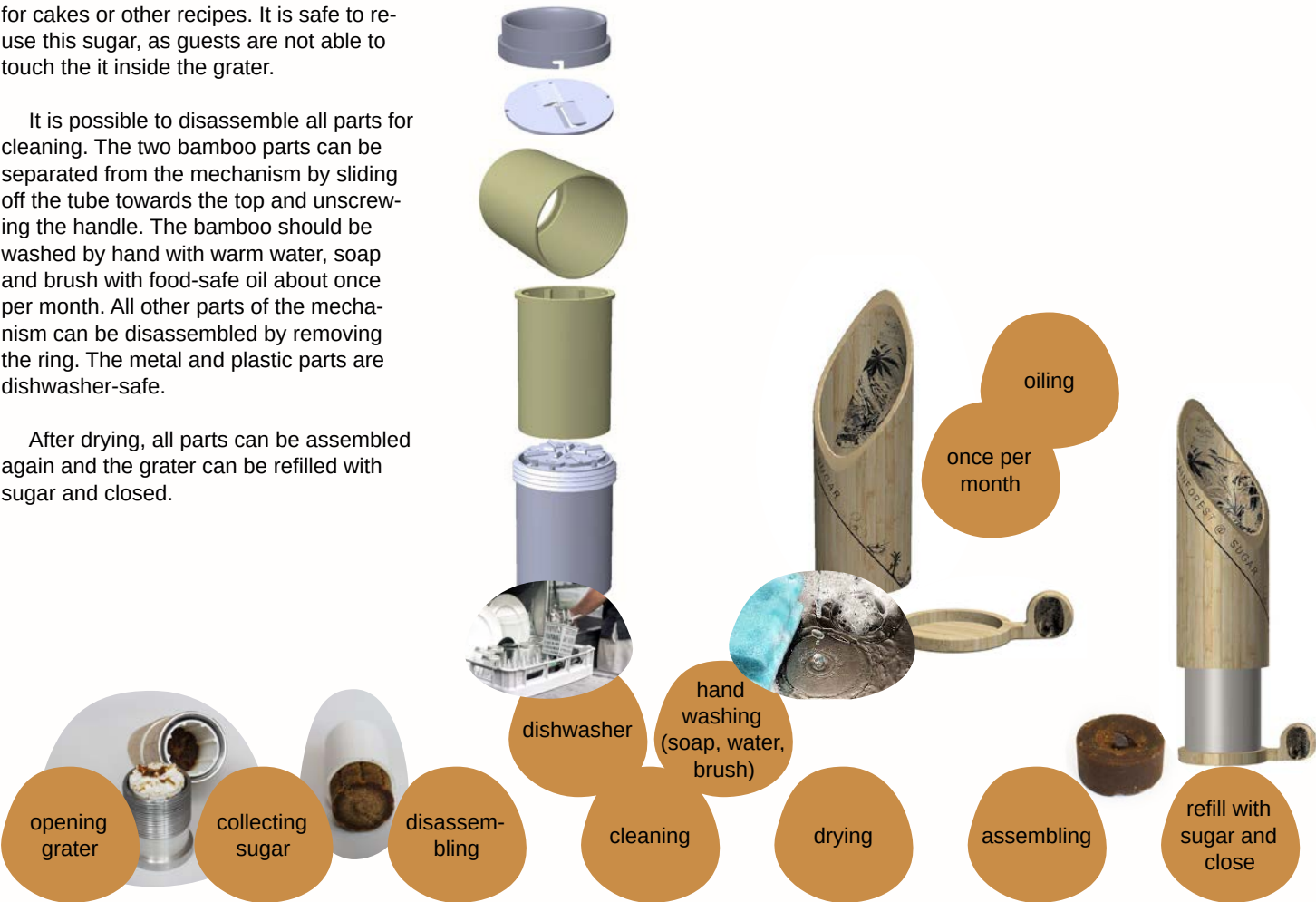


Figure 66: Cleaning

Story

The goal is to let the café guests experience the background story of the Arenga Rainforest Sugar. Storytelling elements are integrated on different layers. The first and most obvious one is the text. Next come the illustrations (explained on page 67), then the general appearance of the grater, the sugar, and the experience of using the grater. Metaphorical elements subtly communicate the story. Extra layers and details can be discovered by the user, stimulating their imagination. Explanation can be found in the information material on the table and on the website. The story is deeply integrated in the final design. Some focus points have shifted and the implementation has slightly changed compared to how the story is explained with the design explorations on page 56. The main elements remain the same.

It is important to communicate that the sugar comes from the rainforest. This is shown with the sugar flower growing inside the rainforest illustration. In this illustration also an Arenga palm tree is depicted in its actual habitat.

Also the small process engravings emphasize the rainforest origin of the sugar and the role of the forest community. These processing illustrations are located around the grating mechanism, where the processing takes place in the tool. This links the decoration to the function of the tool.

The Arenga palm leaf, depicted at the back close to the processing illustrations, symbolises the important role of the tree for the rainforest and the local community, providing them with a sustainable income. The leaf engraving invites the user to put its protecting hand around the rainforest, depicted inside.

The spiral line is circulating around the grater and connecting all the elements to represent this balanced eco-system, where everything is connected. Both the rainforest and the people benefit from each other through the Arenga palm tree. The circular motion of the spiral is continued in the grating rotation actuated by the café guest, who keeps this system running. The handle gives the user an explicit part in the design, serving as metaphorical element for the story and showing the users contribution.



Figure 67: Story

Information Material

On the table, some basic information material about the Arenga Rainforest Sugar can be provided. Depending on the café's preference it can be either a separate flyer, which is inside or next to the menu, or an info box integrated and printed in the menu.

The information material consists of a short text, roughly explaining the sugar's source and mentioning the sugar's health benefits, such as the low glycemix index and the nutrients. A drawing of how the grater is held with the sugar flower coming out is used to illustrate it.

Extra information can also be provided at the shelf (see with the design explorations on page 59), where the café displays the Arenga Rainforest Sugar.



Figure 68: Menu

Website

The website can be reached by scanning the QR code on the bottom of the tool. Next to the QR code is also the web-address written. The website is optimised for mobile phone usage. It is designed in the same style as the bamboo grater with its decorations. The sugar's background story is explained in more detail and illustrated with visual references, clearly linking to the metaphorical elements on the physical grater design. Next to drawings, explaining the process, there should be also video and photo material of the people harvesting and processing the sugar. The character of the website should be explorative and provide different layers of information for the user to discover, but summarise the main information in one quick overview.

A future addition could be some Augmented Reality features, where the user points with the phone camera on a certain element of the grater and gets extra information about this part blended in.



Figure 69: Website and QR code

Business Model

The business model for the Arenga sugar is drafted for selling the sugar products to cafés (business to business), who then sell the products to end consumers. The sugar will be offered in the café with the drinks, as well as sold to the end consumers together with the grater for home use. To reach the cafés, existing distribution channels should be used to introduce the Arenga Rainforest Sugar via local, small scale coffee roasters. Later the selling channels could be possibly extended to sell to delicatessen and ecological shops etc.

The Business Model Canvas (by Osterwalder and Pigneur, source Boeijen, Daalhuizen, Schoor, & Zijlstra, 2014, p. 105) is filled in for the rainforest sugar and tool (see Figure 70), to define the value creation and value capture for the *Forestwise* sugar consumer brand.

Key partners are cafés, coffee suppliers, sugar production, and tool production and repair.

The internal **key activities** consist of organising the sugar and grater tool production, checking its quality, delivering the sugar blocks to cafés, and providing them with the grater tool and background information about the rainforest products.

The **key resources** are the Arenga Rainforest Sugar, an Indonesian network and local experience, and the possibility to provide a transparent tracking system.

The **value proposition** forms the *raison d'être* for the *Forestwise* sugar consumer brand and consists of providing Dutch café guests with a tasty, sustainable and healthy sugar experience with a good story.

External aspects such as **customer relationship** is rather distant and consists of arranging delivery of the sugar (consumable) and making sure the cafés have (well maintained) grater tools (service). **Channels** for this relationships will be mainly coffee suppliers, but also social media, website and email. The targeted **customer segment** are hip cafés and their guests (see page 26, Target group). s

Service

A hybrid model is suggested, where the sugar blocks are sold to the cafés while providing the grater tool as long as they keep ordering the sugar. This means the tool will be rented and must be maintained and replaced if necessary by *Forestwise*. This gives the company control about the products and allows to efficiently use the tools and extend their lifetime by maintaining, repairing and upgrading and eventually recycling (Bakker, Hollander, Hinte, & Zijlstra, 2014).

Costs

The costs for *Forestwise* consist for the grater tool of material costs and manufacturing costs and for the sugar blocks of processing and packaging costs. Labour costs in Indonesia are comparably low, as well as local materials (bamboo and sugar). The other parts of the tool would probably form the biggest costs. Added to this come costs for shipping and service.

Revenues

Revenue is generated by selling the grater tool and the sugar with a premium price and position it in the high end market. The price can be justified by the added value, consisting of the experience, decoration, design, health, taste, and a unique and sustainable product story. It is suggested to sell the sugar blocks for 3€/250g and the tool for 30€ to the end consumer. Cafés only pay for the sugar and get the tool provided for free. For a sugar portion of 4g it would cost the café around 0.05€ per drink, plus labour costs.

Product Category Life Cycle

The sugar grater will start off with the introduction phase after the first model is developed, tested (pilot with 50 pieces), and manufactured. This phase should be kept at a small scale (around 500 pieces) to manage the risk and stay flexible for adaptations and preparation for upscaling production.



Figure 70: Business Model Canvas for Forestwise's sugar brand

Evaluation

The design is evaluated with input from users and cafés. Evaluation criteria are user perception, suitability for its context of use and sustainability.

User study

Research Goal

The goal of the user study is to evaluate the concept by validating assumptions and find points which need to be improved. With the user test it is checked whether the desired experience is achieved as defined in the vision, and what emotions and associations the users experience while interacting with the product. Usability and the understanding of the underlying story of the product are tested.

Setup

The setup for the user study was like a café and participants were served a cup of coffee. They were asked to use the Arenga Rainforest Sugar grater to add sugar to their drink and act naturally and not think out loud. The stimulus material was a functional prototype, with almost realistic look. Some limitations in the working of the prototype were solved by interfering once during the test. The prototype was not suited to grate flower like flakes, but rather smaller pieces, and required more force than the final design would. After the user started grating, the flower shaped flakes were therefore showed with an image and quickly explained. Also some more sugar flakes were added inside the top part of the grater to test how the user would scoop the sugar from there in the cup. The participants were filmed while using the product to analyse their behaviour afterwards. While tasting their drink, printed visualisations of the final design (see appendix) were shown to the test person. A digital questionnaire was filled in, regarding this final design. To not influence the results of the questionnaire no questions were answered about the sugar or its source.

The questionnaire consisted of 10 sections about the appearance, usability, emotions, meanings, Arenga sugar, portion size, story, QR code, and general comments. There were open questions for qualitative insights as well as some quantitative yes / no questions and Likert scale ratings. See appendix for the specific questions.

15 international master students (between 20 and 30 years) from the faculty of Industrial Design Engineering, TU Delft participated individually in the test, plus one student for the pilot beforehand, helping to test and refine the test setup. Half of the participants were female and three were left-handed.



Figure 71: User test setup

Results

Results were obtained by observing the participants using the grater, from their answers to the questionnaire, and some final conversations with participants after the test. The observation notes and the specific questions and all answers can be found in the appendix.

First Impression

When the coffee and the sugar grater were served, most of the participants seemed (positively) surprised. The question about the emotions while first looking at the grater was rated after the test on a scale from 1 (disagree) to 5 (agree). The mean for the emotion “pleasant surprise” was 3.87. “Curiosity” was rated as a stronger feeling in this situation with a mean of 4.53. Thoughts of the participants when first noticing the tool were for example: “Pretty!”, “The material, I love bamboo.”, “very organic and looked earthy”, “An object I have never seen before”, “original”, and “cool looking product”. On the other side also insecurity and concerns were mentioned, such as: “I felt a bit sceptical about whether I would like it”, “I wasn’t sure where the sugar came out of”, “I did not immediately understand how it worked”, but many mentioned they were “intrigued” and “eager” to find out.

Usability

All participants initially looked inside the top, afterwards some checked the bottom side of the tool, expecting a sugar outlet there. Some participants also thought the sugar would be inserted on the top. Many participants expected granulated sugar. One started to shake the tool since he expected the sugar would then come out through the gaps between the blades. Most of the participants however noticed directly the handle and started rotating the base. Associations with pepper mills and a clear parting line between the bamboo and the metal helped for the usage. The rotation direction was directly done right by 11 participants, 3 were hesitant and went a bit back and forward first, 1 (left-handed) first screwed out the base. He only changed the rotation direction when noticing the thread coming out. Although most participants rotated the grater in the right direction, some were answering in the questionnaire that it was not very clear. The handle was used by half of the participants, most of the time with index finger and thumb. Other participants did not use the handle, but grabbed the bottom part with their whole hand. Nevertheless it seemed that the handle was not in the way for those people and still made it clear to them that the bottom part should be rotated. The shape of the handle and the engraved finger print also served as hint for the rotation direction for some participants. The shape was described to be comfortable to touch but not everyone found it comfortable to turn. When starting to grate, most people looked inside the top and held the grater upright. When sugar was noticed to start coming out between the blades,

most participants turned the grater upside down and let the flakes slide in the cup directly. The tool still works this way, but the sugar flower was not observed growing and in one case there was also risk of the tool touching the drink. Only 5 participants (31.3%) did feel the engravings with their fingers.

The average amount of rotations for one portion of sugar was expected to be 2.78, ranging from 0.5 to 5 rotations.

For most of the people it was easy and clear how to slide the grated sugar flakes into their cup. The sugar came loose well and slid easily through the bamboo tube. Some participants ticked with a finger on the side of the grater to make the sugar move slowly with only a small angle, to be able to carefully determine the quantity. 4 of the 16 participants used their spoon to scoop the sugar in their cup. A few people were observed to leave some sugar flakes in the grater, because it was more than what they wanted to use. Everyone put the product back on the table standing, so the orientation seems clear. Most people did not check the illustrations on the grater in detail before they added the sugar, but afterwards while stirring or drinking their coffee.

Grater

The general appearance of the grater was rated as slightly more decorative than functional (mean 4.38/7, 4 would be neutral). Some participants explained this with “Because it looks lovely as a piece of nature with you in the table, but it also has a small handle that makes you think about the functionality of the product”, “It is more like a decoration compared to a normal one, but it is still quite clear that it is used as a grater.”, and “I think it has both characteristics, functionality is achieved by the shredding process that includes an aesthetic value for the outcome”. Three rather critical reactions on the appearance of the grater were “Appropriate to the context of a coffee place, however not really my style.”, “bulky”, and “Might need to become a bit more modern in appearance.”. Furthermore the appearance was commented positively by the participants for example with

- “It does look novel and organic.”,
- “Very natural, decorative. Looks like it will fit in many contexts. Seems attractive to serve food in (trustworthy)”,
- “It makes me perceive the sugar I am grinding as healthier, more natural! I would like it in a café”,
- “It’s not like a standard consumer product, more like something tailored for a cafe.”,
- “I like the combination of the ‘rough’ natural material and the polished design and mechanism.”,
- “It is new and unique, I haven’t seen something like it before. The material gives a natural and raw feeling. The engravings tell a story of ‘handmade’ “.

Those first comments are in line with the ratings on the meanings, associated with the first appearance of the grater. “Natural” was rated with a mean of 4.67 of 5 (between somewhat agree [4] and agree [5]). While using the product the rating for “natural” went down to 4.33. For the meaning “special” the first appearance of the grater was rated as 4.33 and the usage as 4.07. The meaning “authentic” was rated slightly lower with 4.20 for the appearance of the grater, and 3.93 for using it. Furthermore also associations of “homemade” and “traditional” were mentioned by the participants. Some participants elaborated on their rating on the grater’s appearance, to what extend they agreed to the meanings “natural”, “special”, “authentic” with comments like:

- “The materials looked natural and looked authentic with hand-craft skills. Also it felt special because it is rainforest sugar“,
- “Natural because it is made out of bamboo; special because of the combination of shape and materials.”,
- “I think that the wood gives a natural appearance and makes it more authentic. Adding the engraving makes it special”, and
- “I consider it has a natural connection with the materials and the environment but also with the communities that live in certain places. It is special since it puts together aesthetics and functionality.”.

The authenticity of the grater was criticised a bit “Not really authentic because I can see some aluminium coming out of the product, meaning that it is artificially made” and “The mechanism makes it less natural than it seems, but I don’t think that’s a bad thing, its just more interesting.”, Other

associations were “Feels a bit like a souvenir.”, “Reminds me of holidays” and the “feeling of home”.

The participants agreed with 4.53 (of 5) to feel the emotion “curiosity” while first looking at the grater, slightly decreasing to 4.33 while using the grater. “Fascination” (3.73) and “Pleasant surprise” (3.87) were lower while first looking at the product and increased to 4.00 for “Fascination” and 4.07 for “Pleasant surprise” while using it. “Virtuousness” was rated close to neutral (3.13) for both the appearance and usage of the product. Other emotions were added by the participants such as “confusion”, “insecurity”, “calmness”, “relaxation”, “admiration” and “amusement” for looking at the product, and “pleasure” but also “fear of doing something wrong” and “worry” for using the product.

8 of 15 participants (53.3%) did not consider hygiene an issue while using the grater in a café: “It seemed quite clean to use”, “I don’t see many issues with that since I didn’t need to touch the sugar directly with my hand. The “scoop” part of the product could be easily washed.” and “I don’t think it’s a problem if the cafe feels clean to me.”. Other participants were however concerned, because “The metal parts could be dirty without me seeing it”, “sugar attracts flies, and I imagine many users will use their hands to brush sugar from grater into coffee.” and “It didn’t look very hygienic with the ‘tattoo’ style engravings.”, suggesting “perhaps the inside could be made out of metal, which would feel cleaner”. Little remainings of sugar still sticking to the knife serve as a hint for us-

ers to understand the working principle of the grater, but might also be perceived as not clean. Another issue could be left-over sugar flakes staying openly in the grater, in case users grate more sugar than they would use.

Sugar

The participants liked the look of the sugar (flower) with a mean of 5.93, rated on a 7-point Likert scale ranging from “not at all” (1) to “very much” (7). Liking of the smell of the sugar was rated as 4.31 (close to neutral) and the taste as 5.14. While grating only 5 participants (31.3%) noticed the smell of the sugar, and 6 participants (42.9%) noticed the taste of the sugar in their drink.

Comments were

- “The colour is super pretty and looks natural and raw, having the flakes feels fancy.”,
- “It seems like quality sugar”,
- “It feels very raw, not processed. This makes me think that it’s healthier”,
- “It has a natural appearance and I like the sugar flower.”.

“Natural” was rated for the sugar with a mean of 4.57 of 5. The meaning “special” was rated with 4.47 as well as “authentic”, with 4.47. Regarding the emotions about the sugar, participants agreed to “Curiosity” with 4.33, “Fascination” with 4.27, “Virtuousness” was rated 3.13 (almost neutral) and “Pleasant surprise” with 4.00. Eight participants (50%) would prefer the Arenga sugar over regular sugar; “It tastes really nice.”, “Better quality.”, “It looks more natural and more beautiful.”. Seven participants (43.8%) did not mind “I don’t really notice the difference, and the benefit is not imme-

diately clear.”, “I didn’t taste any difference but I suppose it is healthier”, and “Other than the presentation, I can’t think of other characteristic that makes it better to regular sugar, so I could go either way”. Only one participant preferred regular sugar; “It smells a bit caramelized, which I wouldn’t be super fond of in any recipe - for some recipe’s it might work well”.

Regarding the quantity of the sugar, 8 participants (50%) were interested to know the portion size they are taking, because of “weight loss / diet”, “I need to keep track of the amount of sugar I have”, “it is nice to see how much sugar I am consuming” and “So that I know how much is necessary. Right now I think I took a lot, because I did not expect it to sweeten it so much as my drink got really sweet”. A weight indication although would not help everyone since the Arenga sugar is a bit less sweet and one participant said for example “I don’t know how much sugar I would need compared to my normal amount I use”. The other eight participants did not like to know the sugar quantity, because it is perceived as “too confronting.”, “it seems quite natural already, no need for gram calculation.”, “I don’t use sugar that often so no need to watch my intake... also it is a luxury product so I get to treat myself.” and “Usually I just take an estimated amount of sugar and don’t know the exact amount of grams.”.

Story

Most users seemed to understand the main message, where the sugar originates from. Many answered the question about the source of the sugar correctly, with for example

- “from some forest of course”,
- “Some kind of exotic rainforest.”,
- “It’s definitely from rainforest, but don’t know exactly where it is.”,
- “From the Arenga rainforest, it is clearly written on it. The sugar is collected from the top of trees”,
- “somewhere from Southeast Asia”,
- “probably Asia due to the bamboo”,
- “From preserved places in which a sustainable process is done and there is a balance between the community and the product.”.

Several people expected that “Arenga Rainforest” would be a term and one also googled it. Some wrong associations were with sugar cane and Latin America. The question about how it does make the participant feel, knowing where the sugar comes from, was answered with:

- “I feel good that it is organic.”,
- “More appreciative.”,
- “I feel a bit more sustainable and healthy.”,
- “I like to be aware about the origin of what I am eating”,
- “Like I am consuming a more natural product, hopefully helping out the people making it.”,
- “Good! I like consuming food that sustains local economies.”,
- “relieved in the sense that you know the product is not taking advantage of the communities” and
- “Curious to know more about the produc-

tion and distribution.”.

Some concerns were mentioned however and the sugar was not thought to be sustainable by 3 participants (18.8%), because “I don’t get any info. about that.” and “Depends where you get the sugar served. If it is served in the Netherlands I would maybe think of the CO2 emissions that are caused while transporting the sugar from a rainforest area to the Netherlands.”. Concerning answers, where the message did not seem to be picked up correctly, were “Growing it causes rainforests to be chopped down.” and “it demands a high amount of resources and it needs to have a balance with the environment and the crops”. Nine participants (56.3%) on the other side thought the sugar is sustainable and the 4 other participants (25%) thought it to be “more or less sustainable”: “The image communicates a sustainable product, with the colours, materials, story. The engravings and willingness to communicate the story makes it more transparent to me.”,

14 participants (87.5%) said they would like to know more about the story of the sugar, because for example “Sugar is a very important type of food that we intake due its effects on the body. So I definitely want to know more about it.”. Suggestions, where to find the information, consisted of -“a brochure on the table”, -“somewhere printed on the menu”, -“a little text block on the side of the grater”, - “on the body of the grater”, - a “website”, - or “augmented reality on the grater” and 4 suggested a QR code. 14 participants (87.5%) had noticed the QR code on the bottom of the grater during the user test, but only 6 participants (37.5%) would have scanned it. Explanations were - “I never do, I’m not used to. I would have preferred to google the name or find their FB page.”, - “I don’t generally use my phone when in cafés.”, - “I would not scan the code and read online. I would like to read it on the table itself. Also I am with my friend. I would prefer that both of us don’t use our phones.” and - “I noticed it in the end, so i think it needs to be in another place to catch more the attention to be more engaging and make me scan the code.”. Others said to scan it “Because I believe is an interesting thing to learn about, also the design is inviting you to.”, “It’s an interesting product, so I would like to see what I will get.” and “It helps you explore the product for the first time.”.

Discussion

The results of the user test should not be generalised as such, since the study was only conducted with a small amount of participants (16 students) and probably does not perfectly represent the average café guest. Some participants also did not like to put sugar in their coffee and normally drink it without. Additional context factors need to be considered. In a café people might be for example more sceptical and first check the decorations and explanations better. Only the grater was tested with its decorations and no extra information material was used. The users did not receive any specific background information about the Arenga Rainforest Sugar. This probably contributed to the relative low rating for feeling of “virtuousness”, because they did not completely understand the bigger picture and their impact yet.

Limitations of the prototype also influenced the results. Some participants were hesitant because they were afraid to break the prototype. Some were insecure whether it was really a working prototype and one test person just pretended to use it. The perception of the handle was influenced by the quality of the prototype. The handle was perceived as fragile, especially since a lot of force was required, which would not be the case with the final design. The parting line in the bamboo tube, consisting of two parts in the prototype made it furthermore less clear, which part of the grater would rotate. The perception of the hygiene and cleanliness might be also influenced by the quality of the prototype.

The solid aluminium block inside of the grater prototype made the base more heavy than the final design, causing a different equilibrium position. This might have influenced how and where people would hold the grater. Same counts for the engravings; the palm leaf at the back side of the grater was intended to be explored with the fingers while holding the tool upside down, grating. The engravings though were not very deep in the prototype and the users did not hold the tool the intended orientation.

Interfering during the test, where the prototype did not grate nice flakes, interrupted the user and did not let them use the product completely naturally.

The smell of the sugar was probably not noticed by many because of the overruling smell of the relatively fresh linseed oil on the bamboo, which did not neutralise yet. Using the grater upside down did not guide the smell of the sugar towards the user’s face as intended.

Conclusion

It can be concluded from the user test that the grater and the sugar were appraised as very positive and interesting.

However it was not clear to the users that the sugar flakes should come out at the top of the grater. Solutions should be developed to motivate the users holding the grater upright while grating because this way they can observe the sugar flow-er growing. Explanatory illustrations and explanations on the table could be helpful. This information material could challenge the users to create a perfect sugar flower. This can be only done holding the grater in the intended orientation. More pronounced engravings with deeper indents at the back of the tool could support this by guiding the finger position, as well as a more rounded and ergonomic shape fitting the hand.

Another solution should be found for indicating the portion size and for what happens in case people grate too much sugar.

Overall it seems that the vision is achieved and the users perceive the product as natural, special and authentic. They confirm emotions such as curiosity and pleasant surprise and. The main message of the sugar can be conveyed. People understand that the sugar comes from the rainforest and is produced under fair conditions by local communities in a sustainable way. This results in the perception of a natural and healthy product. It should be paid attention to ensure that really nobody associates the sugar with deforestation.

The general attractiveness of the grater’s appearance and the fact that it was rated as decorative also confirms the idea to use the grater as table decoration. It might also draw attention of people not even using sugar.

More conclusions from the user test are translated to recommendations on page 88.

Context

For a successful design it is important that it matches with its context of use and is in line with the practice. In order to evaluate the design it was presented to more than 15 different coffee places in Den Haag with the prototype and some visualisations. Café owners, managers, baristas and waiters were interviewed and asked feedback on the design. The reactions were in general very positive, many assumptions could be confirmed and useful points of attention could be found to refine the design. An overview of the conclusions from the interviews and potentially interested cafés in Den Haag are presented in Figure 72.

The interviews could ascertain what kind of cafés would be interested in serving the Arenga Rainforest Sugar with the grater. It was found that big places, restaurants and more classic places were not so much interested and found the design too complicated and too novel to offer their guests. On the other side small speciality coffee bars could see the added value in this special sugar product. Those places offer a homey atmosphere and personal attention for the guests. They also focus on high quality and prefer sustainable and healthy products. They like to be special and different and also dare to try out some more crazy and unconventional things. Products with a story are appreciated by their guests. Currently there is much attention paid to the source of coffee beans and for example dairy products, but sugar or sweetener are ignored and offer potential

to complete the authentic coffee experience. Different uses of the grater could be imagined by the interviewees, ranging from handing out and explaining the sugar at the bar where they would serve the coffee, to serving the sugar grater with each cup of coffee and ask at the table whether the guests wants sugar, to permanently placing a grater at each table. It was a general wish to receive extra information material with the sugar for the guests, consisting of instructions of use and the product's story. This could be integrated in the grater or be a flyer next to the menu or a info box in the menu. Many places mentioned that their guests like to read this kind of extra information. Depending on how the sugar grater is served it is convenient that it has a heavy base for for stable standing to withstand for example wind outdoors and be easy to serve on a tray.

Premium prices are easy to justify for speciality coffee bars and accepted by their guests. The higher price for the Arenga Rainforest Sugar was seen as worth the product. The business model where the cafés buy the sugar blocks and get the tools provided as long as they offer the Arenga Rainforest Sugar could be confirmed by the interested cafés. They perceived the risk as relative small to try out the new sugar product. They are positive about how their guests react on the new product and how it performs in practice. Practicality issues were not many mentioned and the design was perceived as well thought through. The only concern was rain, when left outdoors. Bamboo was seen as a suitable material choice, although maybe the inside of the

tool where the sugar flower touches could be made more smooth for easy cleaning. Furthermore it is convenient that the tool can be disassembled for regular cleaning with soap and warm water. Refilling was only seen as a burden by some cafés currently using sugar sachets. It was though mentioned that those cause a lot of waste because many of the returned, not used sugar bags are dirty and not reusable anymore. It is convenient that it is well visible when the sugar grater has to be refilled and that it is possible to refill before it is completely empty. They were not concerned about having to refill the tool too often, since sugar consumption is relatively low in general, but difficult to estimate. Many cafés also sell products and were interested to also offer the Arenga Rainforest Sugar assortment in their shop. Many interviewees could well imagine the product for home use or as a gift. Also other potential uses of the sugar were mentioned such as for desserts, baking and cocktails.

The look of the tool was perceived as attractive and matching with the cafés' interior design. It fits well to the bright wood and plants which are often used. One place mentioned to prefer a more minimalistic design (with less decoration) and two others asked for customisation for the café's theme. The presentation of the Arenga Rainforest Sugar was perceived as matching with the story behind. The grater was considered being suitable to promote the cafés sustainability efforts. The general idea of how the story is integrated in the tool was seen as very creative and well thought through. Especially the aspect of seeing the sugar flower growing inside the rainforest was intriguing.



Figure 72: Cafés in Den Haag potentially interested to serve the Arenga Rainforest Sugar with the grater

Sustainability

The first incentive for the design of the grater was to promote the sustainable Arenga Rainforest Sugar with end consumers. All aspects of the design must be in line with the sustainability background of the sugar and the general mission of *forestwise*. The “Ecodesign checklist” from the Delft Design Guide (Boeijen, Daalhuizen, Schoor, & Zijlstra, 2014, p. 65) helped to evaluate the design on the conceptual, product component, product structure and product system level.

Conceptual Level

The concept of the grater for Arenga Rainforest Sugar blocks for cafés fulfils the social need of more sustainable and transparent products, which are consumed with more awareness. The design supports the sustainable business model of wild-harvesting from the rainforest and this way protecting biodiversity, while also improving the livelihood of the local people in Indonesia. For the café guests it fulfils the need of having a positive impact by letting them experience the story and contribute to it. The design furthermore makes a healthier alternative more attractive. The main function of the tool, serving the sugar, is done effectively and efficiently within the requirements of the context. The functions of storing and grating the sugar are integrated and also combined with storytelling and table decoration. The proposal of a modular shelf system for cafés as storage and display with information and decoration also highly integrates functions.

Product Component level

The supply of the materials and production of the parts are determining the impact of the components.

The outer part is made of bamboo, which is a deforestation free and renewable material, locally growing at the location of production. Production waste is minimal because both sides of the bamboo tubes, cut in an angle, can be used and parts of the tubes which do not have the right dimensions can be for example processed into coasters. Bamboo is used for the bigger parts of the product, which may be seen as less “necessary”, since it is a low impact material.

The mechanism is made of a minimal amount of parts and material is tried to be reduced. When selecting the specific materials, recycled metals and recycled or renewable (bio-based) plastics should be preferred. Waste material can be reduced, by machining the cylinders and piston out of pipes instead of solid material. The knife is punched out of stainless steel sheets with minimum waste, and the left parts between the circles can be recycled.

The sugar blocks production requires slightly less boiling and energy than making granulated sugar.

Product Structure Level

The distribution of the grater and the sugar probably causes the biggest environmental impact during the whole product life cycle. Shipping from Indonesia to the Netherlands can be only improved through technological and operational measures, and the use of renewable energy. Regarding the bigger picture, the transportation is similar to (brown) cane sugar or other alternative sweeteners (like maple or agave syrup). Only beet sugar from Europe requires less transport, but is not available as unrefined sugar with molasses.

The sugar blocks can be shipped more compactly than granulated sugar and require only limited packaging. Recyclable material, paper and in cardboard boxes, should be used. Shipping must be organised efficiently to only send full containers. A storage of spare parts in the Netherlands should prevent airfreight.

The products impact during use is minimal. Only cleaning requires resources like warm water and soap.

The grater is driven manually and needs no batteries and electronics. Using the sugar blocks with the grater eliminates the packaging waste of individually packed sugar portions (sachets) and the sugar wasted because people only use part of the portion or return a not used but dirty sugar packet. The grater allows for gradual sugar portions. Presenting the Arenga Rainforest Sugar as something special and valuable should also make people consume it more aware and waste less. When refilling the grater, a continuous sugar flow is ensured and the sugar can be reused after cleaning, so no sugar is wasted.

Product System Level

The design is simple and durable for a long product lifetime. Ease of maintenance and repair can further elongate the lifetime. It is easy to disassemble and access all parts with the modular product structure. This is important for proper cleaning, for maintenance and repairing. If the knife gets blunt for example, it can be quickly replaced with a new one. It is also possible to upgrade or adapt parts. The aesthetic lifetime of the product can be extended by replacing the bamboo parts, allowing for new or different style of decorations.

At the end-of-life, when a café does not use the grater anymore, *Forestwise* can take it back. This is facilitated by the business model, where the cafés do not own the graters but get access as long as they order the sugar blocks. *Forestwise* can reuse the whole product, possibly clean and refurbish it, reuse product components and eventually separate and recycle the materials.

Conclusion

To conclude this report it is reflected on the project outcome and recommendations are given for further development of the design.

The project's aim was to develop a suitable way to serve the Arenga Rainforest Sugar in Dutch cafés. The starting point was granulated, brown Arenga sugar.

The Material Driven Design approach stimulated not to take the starting material as given but to play with texture, shape and process, for finding a more suitable material concept. This also generated a complete understanding of the Arenga sugar. The idea to use traditional sugar blocks and let the user transform them into beautiful sugar flakes was stimulated by this approach. This helps to distinguish the Arenga sugar from other brown sugars.

The final design proposal presents the sugar to café guests in an attractive way as special and natural. The proposal fulfils the design goal. As aimed for with the vision, it lets café guests experience the background story of the Arenga sugar. User tests could show that the target group perceives the sugar presented with the grater as envisioned.

The product's **feasibility** is proven with small tests, a variety of prototypes, and a final user test with a high-fidelity prototype. The working principle could be confirmed. Different scales of production are possible with only minor changes in the design. The different parts of the concept are discussed with the stakeholders to confirm that it can be done.

The **viability** of the product is elaborated with a business model (page 76). The product is expected to survive on a longer term because it builds on the sustainable model of wild-harvesting. The product matches *Forestwise*'s mission with being sustainable on different levels (page 86). It also takes future trends into account. Furthermore, possibilities are incorporated in the design to adapt and improve it in the future. Cafés indicated to be open to try the new design because of the low risk and perceived added value.

The product's **desirability** is indicated by all stakeholders seeing the new design as an overall improvement. The reactions from many users and cafés were positive and most preferred the Arenga Rainforest Sugar with the grater over current sweetener products. *Forestwise* is interested in the design because it helps them to promote their wild-harvested rainforest products and communicate their story to end consumers.

The grater is an innovative design. A similar tool does not exist yet and sugar blocks or flakes are not yet served in western cafés. The design fits well to the practice and its context of use.

Recommendations

The project was conducted in limited time and by one person with a specific skill-set. It is recommended to further investigate and develop some aspects.

Information material (flyer, info box and website) should be developed by a communication designer. In the future it might be also considered to implement augmented reality to elaborate on the story.

A solution should be found to motivate users to hold the grater in the intended orientation and observe the sugar flower growing (page 83).

The knife angle, position and cutting depth have to be refined and fine tuned together with the thread's pitch. The amount of rotations and indications for portion sizes should be also defined. To find a suitable consistency, the sugar block production should be tested together with the details of the grating mechanism.

For user tests on a bigger scale, an adapted prototype should be built with the earlier mentioned improvements.

It is advised to use the Programme of Requirements (page 62) and the proposals of this report for further development and at the same time stay critical and update it with new insights.

Personal Reflection

The project was a great opportunity to combine my interests in sustainability, nature, food, new materials and prototyping.

I tried to be open to experiment with different methods, approaches and focus points. It was a valuable experience to manage my own project. I was able to integrate what I have learned from my studies during the past 5 years. The project helped me to gain more confidence in my way of working as a designer.

Consciously, I tackled the assignment quite broadly in order to cover the bigger picture. This holistic approach and the resulting complexity made it sometimes challenging for me to clearly communicate my project. Also writing this report was quite difficult and I struggled to convey all the thoughts behind the different parts of the design in a logical and convincing way.

This was my first design project with a truly iterative process. It was good to already select a concept at the midterm which allowed for another iteration to detail this design. My clear planning and keeping track of my progress helped me through the project, but it was also good to be open and leave some room for changes.

Working 4 days a week on the project stretched it out over a longer period of time. I could keep some challenges in the back of my mind during the other days and this helped me to zoom in and out on the project. I was highly motivated throughout the whole process and really enjoyed working on the project. I was able to select focus points according to my ambitions and interests, in consequence I can identify well with my project. Working individually was challenging and regularly discussing with stakeholders, fellow students and friends helped me to reflect on my work.

I am proud of the outcome of this project and am happy that my final design got such positive feedback from users and cafés.

It was a pleasure to be able to contribute to *Forestwise*'s work and help them promoting their wild-harvested sugar. It would be a great honour if my design proposal would be implemented in the future.

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Appendix

Content

User Study

Details, questions and results of product evaluation with users.

Project Brief

The project brief as accepted by the board of examiners.

User Study

Consent Form

Consent form for participation in user test

Dear participant,

This study is part of my graduation project at the faculty of Industrial Design Engineering at TU Delft. The goal of the research is to evaluate my product design. You cannot do anything wrong, don't feel observed or under pressure, because if "mistakes" happen it only shows which aspects of the design need to be improved. I ask you to interact naturally with the product. You do not have to say out loud what you think, you may share your thoughts afterwards, when filling in a questionnaire.

The test will take about 30 minutes and consists of two parts: first using the product and second filling in a questionnaire.

Your participation in this test is completely voluntary. If you do not feel comfortable during the test and do not want to continue, you are free to withdraw at any time.

I will observe you discreetly while interacting with the product and take notes. If you agree, I would also like to film in case I miss some details which I would like to review later. The film material will not be shared anywhere and only used by me to evaluate the product design.

My observations of you and your answers to the questionnaire will be treated confidentially and will be presented in my graduation report anonymised.

☐ I agree to being filmed during the test

☐ I have carefully read the above description, asked any questions I had and am aware of my rights. I hereby voluntarily agree to participate in this study.

Name participant

Date

Signature participant

Thanks for participating in my test!

Instructions

Imagine you go to your favourite café with your best friend to have a cappuccino and maybe some cake. You enter the café, find a table and order at the waiter. Please pretend you want to add sugar to your cappuccino, even if you would normally drink it without.

Please take a seat and wait for your cappuccino to be served. Then add sugar to your drink.

Please consider that the design you are using is only a prototype and I will show you later how the final design should look like. I may interfere once because of limitations of the prototype.

Questionnaire

To find the original questionnaire used for the study please check tinyurl.com/arengasugar

Visualisations

The following photos of how the sugar flower should look like were presented to the participant after he/she started grating.



After using the product, this visualisations of the final design were shown to the participants to show them the differences between the prototype and let them fill in the questionnaire considering the final design instead of the prototype..



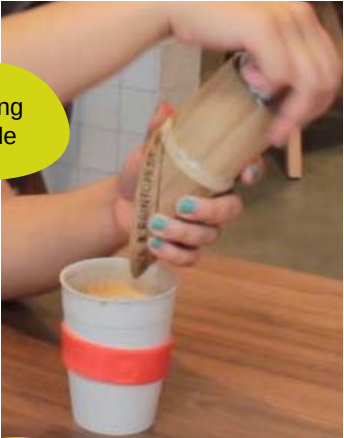
Observations

The following points were noticed while observing how the participants used the product. Reviewing the film recordings of the test helped to notice all the details.

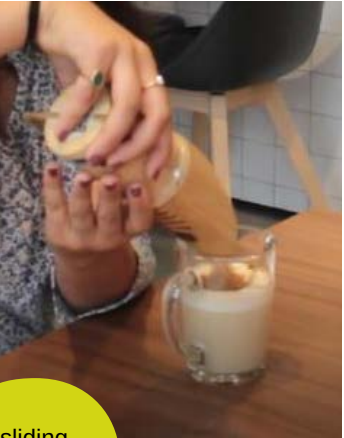
Participant	Looking, understanding	Grating	Use of handle	Holding the tool	Rotating direction	Sliding sugar	Stirring	Other
1 pilot		rests of sugar flakes served as hint			yes, directly good			
2	looks in top, first wants to pour, but then directly starts to turn the handle	yes, no problem	yes, first with thumb	first looking inside top, as soon as sugar comes turns the tool upside down		with two hands, right hand on top, left supporting on bottom, quickly, then taps on bottom to make all bits fall out	yes	
3	grabs spoon and wants to pour sugar from tool to spoon then notices handle and starts turning	yes	not really, uses whole hand	upside down, opening facing her to see what comes out, holds tool in left hand, rotating with right	right	it's too much sugar fer her. uses spoon to only takes a little bit of it		
4	first turns top, while tool stands on table, looks inside top, then tries to shake out sugar through gaps between blades	does not get the grating	careful with handle, because it is a bit loose on the prototype			would use hand to get out sugar flower, now uses spoon for the small flakes	yes	left-handed, googles "arenga rainforest"
5	looks in top, checks bottom, then turns it upside down	first tries to push in the base, then	uses handle swapping between thumb and index, then only index finger	up side down, holds tool in right hand, rotates with left	first wrong direction, until he sees the thread coming out	left hand, shakes a bit to make it slide and control amount	yes	left-handed
6	"Uh, that looks fancy" grabs tool, looks at handle, looks in top, smells	turns up side down and starts grating	not really, later with two fingers	upside down	right	with right hand, pours sugar over the long part of the slide	yes	
7	looks in top and checks decoration	gets it quickly	with two fingers	upside down, almost touches coffee foam with tool, holds it a bit under an angle and looks inside bottom to check for the sugar coming out	right, then hesitates because no sugar is coming	yes easy with left hand	n.a. did not put it in his coffee	
8	looks in top, then checks bottom		no	holds tool upside down in left hand, rotates with righ	right	yes, with left hand, then adds right hand to further tilt the tool starts with right hand, then puts tool in left hand and holds cup with right hand	yes	
9	first grabs with right hand and starts turning with left, then swaps hands, holds tool over cup, expects sugar to come out on bottom, then looks at bottom and turns it upside down		with two fingers, when it gets more difficult he puts his palm around the base	upside down, almost touches coffee foam with tool, holds it a bit under an angle and looks inside bottom to check for the sugar coming out	hesitant		yes	
10	looks in top and start grating, expecting sugar to come out on bottom		grabs handle directly with thumb and index		right	scoops in with right hand, shaking a bit to dose	n.a. did not put it in his coffee	
11	looks inside top, then checks bottom		does not use handle	holds in right hand, looks in top, rotates with left hand first, then turns it up side down	right	uses spoon	yes	
12			does not use handle first, then with two finegrs	upside down, hold left, rotate right	first thinks he should do it back and forward, not rotating	sliding, first with short part, then turns it so it slides over the long part	n.a. did not put it in his coffee	happy to try let come out the sugar flower
13	quick	looks on top to how sugar would come out	does not really use handle, grabs basis around	holds tool tilted but facing upwards in right hand, rotates with left	right	uses spoon to scoop out sugar, spills a bit of sugar	yes	left-handed, "looks like cane sugar"
14	looks where the sugar could come out, touches bottom	yes, no problem	uses handle with thumb and index finger	up side down, but with an angle	right	holds tool in right hand and slides sugar on an angle, ticks with finger to spread sugar on foam	yes	
15	expects the sugar to come out on bottom, then turns it upside down and grates without problem		uses handle with two fingers	upside down	right	yes quickly, holds tool with left hand, but decides not to put all sugar	yes	first puts it back on table laying, but then directly changes it to make the grater stand up right
16	tried to rotate the product at the parting line, which is only at the prototype and not in the final design	thought something has to be put in on top, expects the sugar to come out on bottom		correct, hold in left hand, turn with right	hesitant	carefully slides in while ticking on the tube for slow control	yes	



looking inside



grating



sliding



using handle



grating upside down



rotating on table



with spoon



Appearance

Participant	What did you think when you first noticed the grater?	Would you rate the grater as rather functional or decorative? Please explain why	What do you think of the appearance of the grater?
1 pilot	Where is the sugar? Do I need to put sugar in there?	5 As I dont know how it works (the technical aspects), it seems a big product for just sugar.	Very natural, decorative. Looks like it will fit in many contexts. Seems attractive to serve food in (trustworthy)
2	I did not think it had sugar in it. I thought in the first second it was some cake cause the instruction sheet said that I have to imagine a cake and coffee. But after 2 seconds I figured it must be sugar cause it came with the cappuccino.	3 It is a functional product but it absolutely looks decorative too. I can imagine it going with some themes for some cafes.	It does look novel and organic.
3	The material, I love bamboo.	5 Its more evocative but not more practical than a small bag or using the spoon.	I like the combination of the "rough" natural material and the polished design and mechanism.
4	Pretty!	4 Hard to say with the semi-functional prototype, but can imagine a good balance between form and function.	Appropriate to the context of a coffee place, however not really my style.
5	very organic and looked earthy	5 Looks like a bamboo stem shaped sugar dispenser	Looks ornamental
6	I thought it was something very original. I am not sure I would have recognised that it is a sugar grater, since the shape is very original. However, it is a very cool looking product	7 In my opinion the most functional sugar holder is the traditional one you can find in any cafe. This grater is a very cool product, but I don't see it as very functional compared to the traditional one	It makes me perceive the sugar I am grinding as healthier, more natural! I would like it in a cafe
7	An object I have never seen before	4 It clearly has the function of serving sugar, but it is also nicely decorated	It looks homemade
8	I wasnt sure where the sugar came out of	5 It functions but in a familiar way, the design is whats new	Looks good, close to hand made
9		3 It is more like a decoration compared to a normal one, but it is still quite clear that it is used as a grater.	It's quite nature and reminds me of the feeling of Southeast Asia because of the material. It's not like a standard consumer product, more like something tailored for a cafe.
10	As I worked with brands in my project, I thought about the associations that came to my mind. Bulky, traditional, natural, regional were the words I associated. I thought that I will turn the handle not around the whole product but around itself.	4 It carries both qualities together. wooden body makes it decorative and seeing the result of the sugar you produced made me think it is functional	I would say bulky but traditional and smooth and kitchenware
11	That it was very beautiful but I did not immediately understood how it worked	4 I believe it's both, because although it is very beautiful it still makes its function	I really like it. It reminds me to tropical climates
12	I felt a bit sceptical about whether I would like it. It didn't look very hygienical with the 'tattoo' style engravings. It conveyed some conceptual value though, I was eager to find out how it would work.	4 A bit in the middle, it has many decorative features, a bit too many in my opinion, but I think it does the job	It looks authentic. Might need to become a bit more modern in appearance. I like the QR code for instance
13	Feelings of intrigued, bemused.	5 Grater takes up a large amount of space. Grater also has a fairly distinct appearance, and "presence" on the table.	It's a bit kitch-y, I don't see it fitting in the decor of all coffee shops. That said, the theme does reflect the product and the product's origin.
14	it resembled me an instrument called marimba, I was intrigued to take a closer view	3 I think it has both characteristics, functionality is achieved by the shredding process that includes an aesthetic value for the outcome	I think it attracts the users since it has a particular finish
15	Nice and natural design.	5 It has a really nice. Regarding the functionality I first used it wrong, because I thought that the sugar would come outside the other side of the grater.	Looks really nice, reminds me maybe of holidays, in particular of the island Bali.
16	I saw the wood and I thought that it was a natural something for my coffee	4 Because it looks lovely as a piece of nature with you in the table, but it also has a small handle that makes you think about the functionality of the product	It looks natural, and I like that the metals are most of the times hidden
	mean	4.38 / 7	
		slightly decorative	

Usability

Participant	Was it intuitive for you how to hold the tool? Which orientation? Which hand? Please explain why	Was it clear in what direction you had to turn in order to grate? Please explain why	What's your opinion about the handle?	Did you feel the engraved decorations with your fingers?
1 pilot	4 Seems there is not one right way to do it. Thats why I just did it (not think about it).	6 Natural instinct		No
2	6 I just took a moment to realise from which side the sugar would drop and also because it is not transparent I took a few moments to see the sugar.	7 I would usually use the handle to the right and hence it seemed clear to me. I did not notice the finger print though.	I think functionally it is not very necessary. It does make it easy to turn it around, but how difficult could that be?	No
3	5 The shape at the top is a good hint but I was not sure of how to use the grinding part.	7 The shape of the top part is easy to identify as the pouring part. I related it to a peper or salt grinder.	Its difficult to spin it completely using only one finger.	No
4	3 Had to try twice as I am left handed.	2 Didn't try it for fear of breaking prototype.	Could feel sturdy in final model.	No
5	4 I didnt know to hold it up or directly drop it in the coffee	4 I didnt notice the direction till much later after I saw the thread	Its a bit too small	Yes
6	4 It is quite clear how you should orient it. However, it is heavier than what I would expect just looking at it. Moreover, I am not sure I would need such a big top part for my small cup (i took an espresso)	7 Yes, it is quite clear which one is the top part. The bottom is completely closed and flat. The product is also standing vertically on the table, so that it is quite clear what is the top	It is a bit bulky maybe, but I like the wooden texture	Yes
7	2 The orientation was not clear because I thought I had to turn it upside town in order to let the sugar fall directly in the mug	1 The shape	It could be more shaped like a hand	No
8	5 I took it with my left hand and then used the right to rotate the lever	3 Took a few turns to test	It may feel fragile	No
9	3 At first, I thought the side where sugar comes out should be towards the cup. But it seems that I don't need to pour the sugar directly to the cup after playing with it for a while.	4 There is a handle with finger print on one side, which should be a clear indicator, but the pattern is not very obvious. Probably with more different color or shape.	I'm a little bit worried that it's too fragile. I feel I can break it if using too much force.	Yes
10	3 I had different expectations about the use.	5 It can be clearer, I wanted to turn it around itself	I liked the shape how you hold it	Yes
11	3 So for me it was bit difficult to understand how to hold it and use it initially, I did not know if it should be used upwards or downwards.. Later I understood how to do it	6 This was more intuitive than the position to hold it to	is not so handy to turn it.. but it is an indicator to know which side to turn it.	No
12	6 It felt like those salt/pepper mills	1 I think I just turned it in random directions, as I did not know the function of the flower-style sugar that would come out	Feels like it could break easily, and I am not sure if it helps for direction. Probably it's best to just block the direction in which it shouldn't rotate.	No
13	5 Clearer orientation themes may be helpful	7 I looked at the mechanism before use. That said, this is definitely an issue for the type of person who doesn't pick up things and try to figure out how to take them apart immediately. :D	I think the handle is comfortable, I would rather see an arrow than the fingerprint cue. You can also add in a ratchet clutch mechanism to fail safe this.	Yes
14	4 it was intuitive but, I was not sure whether it should be used in a specific orientation, so I think I was exploring the product at the beginning	5 I think it reassembles other grinders so you can make the association, I was considering whether I should grind first and then twist the grate to pour the content in the cup	it is nice to have it but I was concerned about the grip of the grate when moving the handle.	No
15	4 I used it wrong first and thought the sugar would come outside of the other side of the grater.	3 I am used from other products that the direction is sometimes a bit different and that you don't need to turn the grater.	It's good.	No
16	5 left hand, with an angle of 60 degrees	1 I started moving it in both direction to see which was the one that allowed movement	it is comfortable at touch and when you grab it, but when you rotate it it is not that comfortable	No
	4.13 / 7	4.31 / 7		No: 11 (68.8%)
	neutral, towards intuitive	neutral, towards clear		Yes: 5 (31.3%)

Emotions

Participant	What emotions did you feel while first LOOKING at the grater?				Do you want to add any other emotions?	What emotions did you feel while USING the grater?				Do you want to add any other emotions?	How did you feel about the SUGAR?				Do you want to add any other emotions?
	Curiosity	Fascination	Virtuousness	Pleasant surprise		Curiosity	Fascination	Virtuousness	Pleasant surprise		Curiosity	Fascination	Virtuousness	Pleasant surprise	
1 pilot															
2	5	5	2	4		5	5	4	5 I am very curious about the sugar too.		5	5	3	5	
3	5	4	4	4	4 The curiosity was mixed with confusion at first.	4	3	3	4 Fear of doing something wrong and ruining my coffee.		5	5	4	4	
4	4	3	1	4		2	2	1	2		5	3	2	3	
5	4	4	3	3		4	4	4	2		4	4	4	4	
6	5	5	5	4		4	5	3	4		3	3	3	3	
7	4	3	3	4	-	5	4	3	5 -		4	5	3	4	-
8	5	4	3	4		5	4	3	5		4	3	3	4	
9	4	3	3	4		4	4	3	3 Worried		4	5	4	5 pleased	
10	5	4	5	5	5 Calmness	4	5	5	5 it is not a real feeling but feeling of home		5	5	5	5 no	
11	5	4	4	4	4 Admiration	5	4	4	5		4	4	3	4	
12	4	2	2	2	2 Insecurity - please note that I didn't really want to have the sugar in my coffee	4	3	4	4		5	5	3	4	
13	5	4	2	4	4 Amusement. It's definitely more fun than generic sugar.	5	5	2	4 See above.		5	5	2	3	
14	5	4	1	4	4 A particular connection with my childhood memories related to the musical instrument	5	4	1	5 pleasure in the sense that the grater is functional and the fact that the movement is smooth		4	3	1	3	
15	4	4	4	4	4 relaxed	4	4	4	4		4	4	4	4	
16	4	3	5	4		5	4	3	4		4	5	3	5	
	4.53	3.73	3.13	3.87		4.33	4.00	3.13	4.07		4.33	4.27	3.13	4.00	
	/ 5	/ 5	/ 5	/ 5		/ 5	/ 5	/ 5	/ 5		/ 5	/ 5	/ 5	/ 5	
	Curiosity	Fascination	Virtuousness	Pleasant surprise		Curiosity	Fascination	Virtuousness	Pleasant surprise		Curiosity	Fascination	Virtuousness	Pleasant surprise	

Meanings

Participant	What meanings do you associate with your first impression regarding the APPEARANCE of the grater?			Can you explain why?	What meaning would you associate with USING the grater?			Can you explain why?	What meaning would you associate with the SUGAR?			Can you explain why?
	Natural	Authentic	Special		Natural	Authentic	Special		Natural	Authentic	Special	
1 pilot												
2	4		4	4 It looks natural but still quite fine and looks like it was industrialised due to the metal, smoothness and finishing.	5	5	5	5 I don't think I ever grated sugar.	5	5		5 I think it is made from something natural or organic and that it is not refined
3	5		5	5 It is new and unique, I havent seen something like it before. The material gives a natural and raw feeling. The engravings tell a story of 'handmade'	5	5		5 The mechanism makes it less natural than it seems, but I dont think thats a bad thing. its just more interesting.	5	5		5 Its different to what I know, the shape looks awesome, it looks raw and interesting.
4	5	2		4 Feels a bit like a souvenir.	4	3		3 Grater did not really function.	5	4		4 Good taste and seems handmade.
5	5	3		4 The materials looked natural and looked authentic with handcraft skills. Also felt special becasue it is rainforest sugar	5	3		3 It seemed similar to a salt or pepper shaker but larger and in wood	5	4		4 Color and texture helped with the associations
6	5		5	5 It's a very original object, and I like the combination of bamboo and sugar. I immediately thought about sugar cane	2	2		4 The mechanism does not feel like natural, since it is a real metallic blender. However, it feels very original	3	4		4 I did not feel any particular emotion for the sure. I suppose that I perceived as more natural because of the wooden enclosure
7	4	2		5 Natural because it is made out of bamboo; not really authentic because I can see some aluminum coming out of the product, meaning that it is artificially made; special because of the combination of shape and materials	2	2		4 The weight of the product was unexpected	5	5		4 Its shape reminds of a rose and/or some minerals. Pretty to look at.
8	5		5	5 It looks somewhat hand made, and different to other sugar dispensers	4	5		5 Seeing the blades rotating broke the natural feel a bit but not much	5	5		5 Reminded me of a type of sugar from Mexico
9	5		3	4 Its material is quite natural. The shape is different from a regular grater. But it's more like a handcraft (also because it's a prototype), therefore, it's less authentic compared to a regular product.	5	3		4 The meaning of using the product is directly related to the quality of the product. Therefore, it's the same as the previous rating.	5	5		5 The dark sugar feels more natural compared to regular sugar. It's made by myself and the shape is special.
10	5		5	4 I can understand the capabilities of the material limits, but I would prefer abit more curves	5	5		4 Regarding the special meaning. I already know this feeling from some other products	5	5		5 I had never see the sugar like that before, it looks natural
11	4		5	5 I think that the wood gives a natural appearance and makes it more authentic. Adding the engraving makes it special	4	3		5 Quite an innovative way to add sugar. I believe that if the prototype was working more smoothly it would have felt mroe natural	4	4		5 Is quite a new way of adding sugar, although I suspect this is more natural an preprocessed version of it. Although we are not used to it..
12	4		5	3	5	5	3		2	5	5	
13	5		5	5	5	5	5		5	3		3 Lowered score due to the context -- if I'm in a coffee shop I'm aware that everything is mass produced or commercialized.
14	4		5	5 I consider it has a natural connection with the materials and the environment but also with the communities that live in certain places. It is special since it puts together aesthetics and functionality.	4	3		4 I felt triggered about the use and the product itself, therefore, I wanted to explore the possibilities regarding different positions and the balance of its weight	5	3		3 It resembles me the sugar that sometimes it's used in my country to prepare pastry and beverages. So I think in that sense it is familiar to me.
15	5		5	4 Reminds me of natural materials and Bali.	5	5		4 Reminds me of natural materials and Bali.	5	5		5 Maybe brown sugar looks appears more natural than white sugar. Also, the flower appears special to me.
16	5		4	3 the textures and materials made me think about the nature.	5	5		3 The feel of the wood and the smell of it		5		5 you dont expect the form of a flower and that makes it very special
	4.67	4.20	4.33		4.33	3.93	4.07		4.57	4.47	4.47	
	/ 5	/ 5	/ 5		/ 5	/ 5	/ 5		/ 5	/ 5	/ 5	
	Natural	Authentic	Special		Natural	Authentic	Special		Natural	Authentic	Special	

Sugar

Participant 2 when tasting the sugar:
“It’s awesome! What is it?”

Participant	Did you notice the smell of the sugar while grating or serving?	Do you like the smell of the Arenga sugar?	Did you notice the taste of the sugar in your drink?	Do you like the taste of the Arenga sugar?	How do you like the look of the Arenga sugar (colour, texture, shape)?	Can you explain why?	Do you prefer the Arenga Rainforest Sugar over regular sugar?	Can you explain why?	Do you regard hygiene an issue while using the grater? Why
1 pilot	No	3		4	6	The color makes it seem like a healthier option	I do not mind	I dont really notice the difference, and the benefit is not immediately clear.	
2	No	4	No	7	7	It doesnt look unhealthy, that's the main reason why. It could not be completely healthy but at least doesnt look like so.	Yes	It tastes really nice.	yes The grater as of now doesnt look completely clean and I am using it would be messy if it came into contact with liquids.
3	Yes	4	No	5	7	The color is super pretty and looks natural and raw, having the flakes feels fancy.	I do not mind	I would have to try it a couple of more times to be sure I like it.	no I did not think about it being an issue while I saw it or used it.
4	No	4	Yes	3	7	It seems like quality sugar, great for baking.	Yes	Better quality.	yes Don't want people's hand biomes in my coffee.
5	Yes	3	Yes	4	4	I am not very convinced by the sweetness through the color and the texture.	I do not mind	I dont know how much sugar I would need compared to my natural amount I use	no It seemed quite clean to use
6	No	5	No	5	6	The smell of wood was stronger than the one of the sugar, and I am not sure I liked it. I didn't taste any different compared to normal sugar	I do not mind	didn't taste any difference but I suppose it is healthier	no
7	No	2			5	It feels very raw, not processed. This makes me think that it's healtier	I do not mind	I almost never use sugar. I never add it to drinks, only use it while baking something.	no I don't see many issues with that since I didn't need to touch the sugar directly with my hand. The "scoop" part of the product could be easily washed.
8	Yes	5	No	4	6	I like the shape of a flower it forms	I do not mind	Other than the presentation, I cant think of other characteristic that makes it better to regular sugar, so I could go either way	yes The metal parts could be dirty without me seeing it
9	No	4	No	6	6	It's natural and the color looks of high quality.	Yes	It looks more natural and more beautiful.	no I don't think it's a problem if the cafe feels clean to me.
10	No	7	Yes	7	7	I already know that white sugar is quite harmful, somehow it appeared to be more natural to me	Yes	I would prefer to have it when in need, normally I dont use sugar	yes It must be clean each time I get the sugar, nobody should touch it
11	No	5	Yes	6	6		Yes	Although if there is some sugar already there already it might generate some problem	no
12	Yes	3	No			I did not taste it - Nyckle	I prefer regular (white or brown) sugar	It smells a bit caramelized, which I wouldn't be super fond of in any recipe - for some recipe's i might work well	yes Especially the long trail it covers between grating the sugar and putting it in your cup. The sugar has to go through this piece of bamboo, which probably everyone has touched. That is a bit of an issue for me.
13	No	5	No	6	5	I like the idea and shape, but it also really reminds me of beef jerky, something I don't want in my coffee. There's also a defined stickiness that throws me off a bit	Yes	sugar attracts flies, and I imagine many users will use their hands to brush sugar from grater into coffee.	yes sugar attracts flies, and I imagine many users will use their hands to brush sugar from grater into coffee.
14	Yes	5	Yes	4	4	I think I am familiar to it and I've already tried in different beverages and pastry so I like it. The shape is quite interesting since you can shape the flakes and put the on top of the beverages as a decorative piece	Yes	I think for some products it adds a special flavor and its content is less sweet	yes you explore the product and sometimes control for that kind of factors
15	No	6	Yes	6	6	It has a natural appearance and I like the sugar flower.	Yes	The sugar tastes good, but I don't know a lot of background information about Arenga Rainforest Sugar.	no I think at the cafe they would change the sugar and clean the grater sometimes.
16	No	4	No	5	7	it is unexpected to see the sugar in another form that is not small particles	I do not mind	i like the form, but i didnt like that i needed to add more sugar to taste it	no
	No: 11 (68.8%)	4.31	No: 8 (57.1%)	5.14	5.93		No: 1 (6.3%)		No: 8 (53.3%)
	Yes: 5 (31.3%)	/ 7	Yes: 6 (42.9%)	/ 7	/ 7		Do not mind: 7 (43.8%)		Yes: 7 (46.7%)
							Yes: 8 (50%)		

Portion Size

Participant	How many turns would you have done for one portion of sugar?	Would you like to know how much Arenga sugar you took? (in grams / sugar cubes / sachets / tea spoon) Can you explain why?	Where would you integrate an indication for the quantity of sugar?
1 pilot	3	3 No, I would just taste Too confronting.	Nowhere
2	Atleast 4	4 Yes So that I know how much is necessary. Right now I think I took a lot, because I did not expect it to sweeten it so much as my drink got really sweet!	On the cylindrical body
3	until I had enough sugar, maybe four.	4 Yes Its easier to know if I would like more. I dont like my coffee to be too sweet.	In the rainforest image
4	Half a turn.	0.5 No, I would just taste I don't use sugar that often so no need to watch my intake... also it is a luxury product so I get to treat myself.	At the handle at the bottom
5	5	5 Yes I cant compare to my usual amount	At the handle at the bottom
6	I did around 3, but I would have added for sure more sugar	3 Yes It is always good to limit the use of sugar, and I would like to be aware of the quantity I am using	In the rainforest image
7	2	2 Yes To keep track better	At the handle at the bottom
8		3 3 No, I would just taste I dont control my food like that	In the rainforest image
9	Two	2 No, I would just taste I don't care about the sugar I take. So no need to bother.	Nowhere
10	2	2 No, I would just taste it seems quite natural already no need from gram calculation	At the handle at the bottom
11	3 or 4	3.5 No, I would just taste	At the handle at the bottom
12	2	2 No, I would just taste	At the handle at the bottom
13	given the amount that came out from a half turn, something between 1.5-3 turns.	2.5 Yes weightloss/diet	At the handle at the bottom
14	three or so	3 Yes I need to keep track of the amount of sugar I have	rain forest image and in the body with a transparent measure
15	3	3 No, I would just taste Usually I just take an estimated amount of sugar and don't know the exact amount of grams.	At the handle at the bottom
16	one, max two	2 Yes it is nice to see how much sugar I am consuming	In the rainforest image
		2.7 No: 8 (50%)	
		Yes: 8 (50%)	

Story

Participant	Where do you think the sugar comes from? What did you take away from the background story of the sugar?	Could you recognise the engraved illustrations?	How does it make you feel knowing where the sugar comes from?	Do you think the sugar is sustainable? Why?		Would you like to know more about the story of the sugar? If yes, where would you like the information to be?	
1 pilot				Yes		Yes	
2	I am thinking it came from some forest of course, but may be from sugar cane?	More or less	I feel good that it is organic.	Yes		Yes	A brochure on this table. Sugar is a very important type pf food that we intake due its effects on the body. So i definitely want to know more about it. But I would not scan the code and read online. I would like to read it on the table itself. Also I am with my friend. I would prefer that both of us don't use our phones.
3	Some kind of exotic rainforest.	Yes	Curious to know more about the production and distribution.	Yes	The image communicates a sustainable product, with the colors, materials, story. The engravings and willingness to communicate the story makes it more transparent to me.	Yes	Probably somewhere printed on the menu, or at a website I could look for.
4	From the Arenga rainforst. I did not get much background.	Yes	More appreciative.	No	Growing it causes rainforests to be chopped down.	Yes	In an unobtrusive place, available upon request.
5	Rainforests	More or less	I feel a bit more sustainable and healthy	More or less	Because it is hand made and comes from natural sources and processes	Yes	VR or AR on the tube
6	From the Arenga rainforest, it is clearly written on it. The sugar is collected from the top of trees	Yes	I like to be aware about the origin of what I am eating	Yes	Because of the use of bamboo	Yes	
7	From Arenga rainforest	Yes	Good! I like consuming food that sustains local economies	Yes	Because of the origin and the product suggests it	Yes	In a booklet on the coffee table
8	Some rainforest, I figure Latin America	Yes	Like Im consuming a more natural product, hopefully helping out the people making it	More or less	I dont know the details about that particular rainforest	Yes	Maybe also engraved on the cilinder Just a short paragraph
9	Maybe somewhere from Southeast Asia or South America. It's very natural.	Yes	The illustrations of trees. It's definitely from rainforest, but don't know exactly where it is.	No	I don't get any info. about that.	No	
10	Arenga rainforest	Yes	trust more	Yes	wooden product, seeing the production, color of the sugar, rainforest name	Yes	maybe on the main body maybe as a QR code somewhere dont know
11	some tropical country probably asia due to the bamboo	Yes	Is nice to have a natural indication	Yes		Yes	maybe a QR, to find out more info..
12	I did not read the rainforest engraving at first	No	Okay-ish. It is a long way from here though. Not sure about the sustainable aspects of that.	No	See above ^^	Yes	Perhaps in a little text block on the side?
13	latin america, jungle/rainforest -- peru or brazi.	Yes	better than using plain sugar	Yes	color and visual cues of the elements	Yes	
14	From preserved places in which a sustainable process is done and there is a balance between the community and the product. Could be the amazonian region which is rich in resources and the rain forest looks alike	More or less	relieved in the sense that you know the product is not taking advantage of the communities	More or less	it demands a high amount of resources and it needs to have a balance with the environment and the crops	Yes	in a scannable mean such a qr or a leaflet
15	From the rainforest. That it is produced naturally.	Yes	Depends where you get the sugar served. If it is served in the Netherlands I would maybe think of the CO2 emissions that are caused while transporting the sugar from a rainforest area to the Netherlands.	More or less	See answer above. However, I do think that it is natural, which is a sustainable aspect.	Yes	Maybe have a small leaflet close to the grater.
16	I just know the name in spanish "caña"	Yes	I guess that from the forest	Yes	I think that yes because of the use of wood for it	No	
		No: 1 (6.7%)		No: 3 (18.8%)		No: 2 (12.5%)	
		More or less: 3 (20%)		More or less: 4 (25%)		Yes: 14 (87.5%)	
		Yes: 11 (73.3%)		Yes: 9 (56.3%)			

QR Code

Participant	Did you notice the QR code at the bottom of the grater?	Would you have scanned it? Why	
1 pilot	yes		
2	yes	No	As my previous answer explains.
3	yes	No	I never do, Im not used to. I would have prefered to google the name or find their FB page.
4	no	No	I don't generally use my phone when in cafes.
5	yes	Yes	Curious for more information
6	yes	Yes	I would be curious to see at which webpage the product is connected to
7	yes	No	Sometimes I do not want to use my smartphone in cafes (especially if I'm with someone)
8	yes	No	I never scan those things
9	yes	Yes	It's an interesting product, so I would like to see what I will get.
10	no	No	i didnt think that it is a QR code
11	yes	Yes	Because I believe is an interesting thing to learn about, also the design is inviting you to
12	yes	Yes	To know how it works exactly, or to learn more about the sugar
13	yes	No	because fuck qr codes.
14	yes	Yes	It helps you explore the product for the first time
15	yes	No	I forgot to scan it, but probably it is nice to scan it to find out further information.
16	yes	No	I noticed it in the end, so i think it needs to be in another place to catch more the attention to be more engaging and make me scan the code
	No: 2 (12.5%)	No: 10 (62.5%)	
	Yes: 14 (87.5%)	Yes: 6 (37.5%)	

General Comments

Participant	General comments and tips for improvements. Please share your thoughts
1 pilot	
2	I like the idea behind and really want to know more about the sugar
3	I think the first interaction with the product is awkward, it really made me curious, but I was also intimidated by it.
4	
5	Try AR for the story
6	Cool product, even if it seems a bit over engineered (this without knowing anything about this specific type of sugar. Perhaps you really need this blades system)
7	Innovative product but I would love to know more on the origin and story of the sugar. How does it end up on the coffee table in that shape.
8	Looks pretty good. Just the expected problems from a prototype, I was worried to break the handle cause the thing got hard to rotate. Maybe add some color. Show the most important facts or something about the sugar on the product itself, and then maybe more details on the QR.
9	It would be nice if I can also see the actual sugar flower.
10	arenga name can be more visible in terms of the angle that you see it when you use it
11	i love it! Good job
12	Perhaps the inside could be made out of metal, which would feel cleaner?
13	discuss in person
14	I like the fact that you addressed the factors of the object such as the engravings, the mechanism and the outcome separately
15	
16	maybe you can have a small base for it with more info about sugar and the qr code