GroundUp: Coffee, waste or resource?

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Abstract

The popularity of the coffee beverage causes for a lot of by-products to be accumulated. The high coffee demand generates organic waste in the form of spent coffee grounds, the residue left after extraction. This is often discarded as waste on a landfill, causing environmental damage due to the release of toxins from the circumstances created on a landfill. Spent coffee grounds are a nutrient rich sustenance which has multiple properties that can be utilized. By exploiting these properties, the spent coffee grounds can be seen as a resource rather than waste. In this project different utilizations are proposed in the form of products. The utilizations used are; odor neutralization, fertilizer, & filler material. In addition a service is proposed, in collaboration with coffee shops, for the collection of spent coffee grounds to get enough of this reusable resource.

Keywords

Spent coffee ground, valorization, waste-prevention

Total word count: 8932

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Iteration 1: Scoping

Global waste buildup has become a big environmental concern. A lot of objects of substances we use are seen as single-use and are after use often simply discarded to landfills or incinerated. In this project I've looked into the possibilities of the use of a food resource that is at the moment commonly single use and discarded in a sustainable way.

1.1 Food waste problem

In the last couple of years, there has been a growing concern about food waste (Schanes et al., 2018). The main issues are resource depletion and greenhouse gas emissions. A large contributor to these environmental impacts can be traced back to private households, especially in developed nations (Schanes et al., 2018; Quested et al., 2013). The European Union alone contributes approximately 88 million tonnes of food waste each year (Scherhaufer et al., 2018). The disposing of this food waste is often done in landfills or incineration.
Even though this problem has gained increased interest from local, national, and European policymakers and international organizations (Schanes et al., 2018), the problem is still a complex and multifaceted issue. O'Connor et al.(2021) explains the solution to the food waste problem stems from the prevention of production and the valorization of it. Waste valorization is a sustainable way of creating value-added products from waste by means of recycling, reusing, composting, or creating sources of energy (Kabongo, 2013).

1..2 Exploration

After analyzing the problems involved with food waste I decided to focus on food waste valorization. It best suited my personal identity and vision for the creation of sustainable practices in a process. As explained in my vision I believe it is the role of the designer to bridge environmental/ sustainability issues with society. The designer should try and find harmony with both aspects for them to prosper. Valorization is such a practice.

Ideation
To have a new point of view on food waste I had several ideation sessions to create new perspectives on how food waste can be viewed. By doing a 'quick and dirty' brainstorm session I came to the conclusion that food waste could be viewed as a usable material. The reasoning behind this is that by forcing myself and others to view the otherwise regarded waste as a "new" material option, we could see how it can impact the way that we handle trash. I've also found that, at this moment, the prevention of food waste has little visibility to other people. This visibility reflects on the social norms surrounding pro-environmental behaviors such as recycling and limiting food waste (Quested et al., 2013). Less visible activities are more often disregarded in comparison to visible activities.

For the next brainstorm session I focused on material exploration (see Appendix). The four main categories that submerged from this were:

- Sustainable materials
- Biodegradable
- Waste management
- Emotions of making

From these categories, I came to my main focus points:

Reshape/Recycle: To have a sustainable impact the material should be well considered, don't use the new if the old is an option.

New value: The creation of new value means (to a certain extent) the elimination and or reduction of wasted material by creating a new function.

A new form of function: For a material to be reused does not mean that it should have the same function as it did prior.

First-person perspective

Whilst already having a better understanding of where my material exploration was headed. It felt like I needed to narrow down the definition of food waste. Since different types of food produce different types of waste, different types of waste, in turn, require different types of solutions. To define which kind of waste I would be focusing on I decided to use the first-person perspective to see what commonly regarded food waste I could find.
Using this perspective, I've logged all things that I discarded as food waste (either edible or non-edible) or if I reused or recycled food waste for four days (see Appendix).

From this experience, I became more aware of my trash use throughout the day. Most of my food waste went into the trash bin due to not having an opportunity to compost in my city apartment. This made me more actively look for green waste bins when I was outside the apartment. Often with no success. Leftovers from meals prior to this experience I already saved often for another day, otherwise, I would try and reuse the scraps if possible. This awareness of not wasting leftovers didn't change much during these days.

What surprised me the most was the amount of coffee ground I threw away in a day. Prior to this task, I expected most of the food waste to come from making dinner. Since I usually cook quite extensively. While this still was a significant amount. The coffee ground was the largest amount of single product waste. This made me reflect on my coffee usage and how popular coffee is in my surroundings. Therefore I decided that for my next phase I would look into coffee ground waste (e.g. spent coffee ground).

Hands-on exploration

For this phase coffee ground was explored as a material, and how it would or could affect other material properties. Three different types of test materials were made. Below you will find how the materials were made and what the preliminary conclusions are.

1. Coffee ground mixed with fruit paste

The spent coffee ground is mixed through a paste made from apple scraps. Four mixes were made; first the controller of only apple scrap paste, second containing coffee mixed into the apple scrap paste, third an addition of sugar to the apple coffee mixture, and fourth a larger amount of coffee added to the apple scrap paste. These mixtures were placed in an oven at 70 degrees Celsius, to be dried. After a drying time of 9 hours, the dried pastes were removed from the oven (see figure ...). This process can be optimized with the use of a drying oven, based on my personal experience. In this situation there was no access to a drying oven, thus a regular oven was used.

The dried mixes gave an interesting consistency, after drying they became leather-like husks in the way that they are flexible. The control did not differ much in the flexibility compared to mixes 2 and 3. However, the control was less sturdy than mixes 2 and 3. Mix 4 is the least flexible of

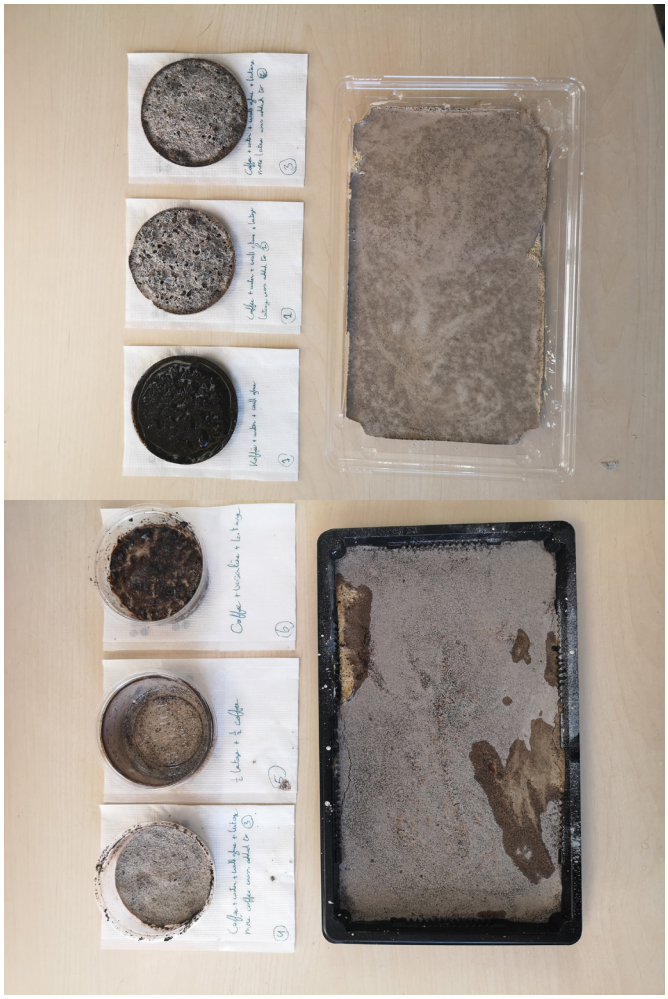
all samples, it being the most compact. There was little to no noticeable difference found in mixes 2 and 3.
The leather-like consistencies created from these mixes, create possibilities for further explorations. Applications yet to be found and tested.

2. Coffee ground mixed with glue-like substances

The spent coffee ground was mixed into different concentrations of latex and glue. These samples were kept in an open-air container so the mix could be set. The six samples can be viewed in .... .
These samples soon turned out to be a not-suitable material. All mixtures faced similar problems. They took days to set and would not hold their shape when removed from the containers. The biggest problem is the amount of mold that would infest in all of the samples.
Thus concluding that in this shape and form it is not a suitable material.

3. Coffee ground mixed in plaster

The spent coffee ground was mixed in 2 badges of plaster with different concentrations of the coffee ground. They were set in open-air containers to dry.



Badge 1, with the lesser concentration of coffee ground was completely dry in 2 days. The coffee ground colored the plaster in a naturally pleasing tint. Even when dry the coffee gave a slight aroma. The material is sturdy, the coffee did not affect the structural integrity of the plaster material.

Badge 2, with the larger concentration of coffee ground dried in approximately 5 days. The coffee ground colored the plaster even more than badge 1. After the drying period this badge was starting to be covered in mold. However, the encounters with the mold was less compared to the mixes from exploration 2. The mold likely forms due to the longer drying time, the material being more porous and the open-air containers giving more opportunity for contamination by fungi/microorganisms. Furthermore, the structural

integrity seemed lessened by the large amount of coffee ground added.

Due to the plaster coffee material holding its structural integrity for half of the results of this exploration. Let it be believed that opportunities for this material can be created as a natural dye and filler material. This needs to be further explored and the avoidance of molding needs further research.

1.3 Conclusion

Using the experience gained from hands-on exploration and brainstorm session(s), I'm able to see a clearer direction of where my project is going. In the preliminary research on food waste it found how big the impact of waste can be, due to resource depletion and greenhouse gas emissions. This needs to be further assessed for coffee grounds specifically. The material exploration gave insight into how coffee could be incorporated into materials. The properties of coffee need to be further researched and how materials can benefit from the involvement of coffee.

Iteration 2: Quality research on spent coffee grounds

2.1 Related work coffee ground

Coffee is enjoyed all over the world, lending itself to being one of the most popular beverages. It is estimated that there is a global consumption rate of 2.25 billion cups of coffee per day (Mayson & Williams, 2021). Here in the Netherlands alone, an average person drinks four cups of coffee every day(CBI, 2021). Making coffee an important player in the global economy. As of now, coffee is the second most traded commodity globaly (Zabaniotou & Kamaterou, 2019;,15).
The high coffee demand causes a lot of organic waste to be accumulated in the form of spent coffee grounds (SCG). This has become difficult to manage properly due to the fact that waste accumulation is rapidly increasing (Kim et al., 2017). Jimenez-Zamora et al. (2015) talks about how coffee companies produce about 2 billion ton of organic waste each year. This organic waste consists of by-products created during or after making coffee, the largest part consisting of spent coffee grounds and coffee silverskin. Often this waste ends up at a landfill. As seen in figure 1 of the current succession of the coffee product service.

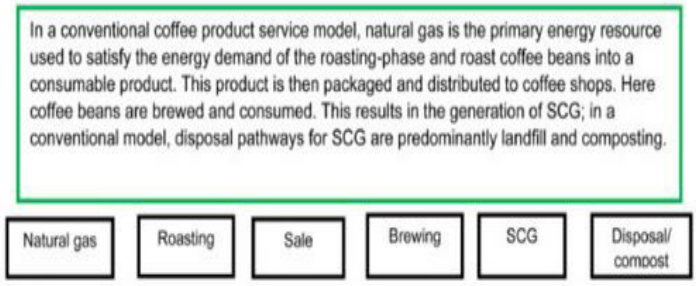


Figure 1. (Mayson & Williams, 2021)

This is not only a wasted process but also a wasted resource. Spent coffee ground has a rich source of fatty acids, amino acids, polyphenols, polysaccharides, minerals, and other viable nutrients (Zabaniotou & Kamaterou, 2019). Because spent coffee ground has such rich organic components, its direct disposal in landfills will lead to many environmental problems. Spent coffee ground needs an elevated oxygen supply to decompose in a landfill, which causes the release of caffeine, tannins, methane, and polyphenols into the atmosphere (Atabani et al., 2022; Kanniah, 2020). Increasing air pollution. The potentially high concentrations of spent coffee

grounds on landfills may pose an extra risk to groundwater or soil contamination (Atabani et al., 2022).

Despite these environmental concerns, the coffee demand continues to grow, on average there has been an annual growth in the coffee trade of 1.9% (8). To combat the demand and decrease the environmental impacts, new ways of processing the spent coffee ground are needed. For this project, this will be looked at by using valorization methods as explained in prior chapters, mainly by recycling and reusing.

2.2 Properties of coffee ground

To be able to optimize the processing of spent coffee ground into products, I've researched and summarized the different properties the spent coffee ground contains.

Odor neutralization (deodorization)
Coffee grounds have a natural odor-neutralizing factor. Spent coffee grounds remain to have this property. As shown by KAWASAKI et al. (2006) the carbonaceous materials in coffee can absorb odorous compounds such as ammonia thus removing potentially unwanted smell.

Fertilizer
Nitrogen is essential for plants (Smith et al., 2009). They play a role in the production of amino acids, proteins, nucleotides and nucleic acids, and a large amount of other structures and molecules like chlorophyll. Spent coffee grounds are rich in organic nitrogen. This high nitrogen content in the spent coffee grounds causes it to be a good source of fertilizer, soil improver, or to be used in compost (Vítěz et al., 2016).

Material production
Due to the high moisture content of spent coffee grounds it needs to be dried first before it is incorporated into a binder material (Saberian et al., 2021). This could have a good application as a non-structural filler material. Due to the high compressibility of spent coffee grounds, it is unadvised to be used for load-bearing structures without the necessary binders (Saberian et al., 2021).
Other possibilities are in the use of bioplastics fermenting the extracted starches and sugars to poly lactic acids for instance.

Biogas (energy recovery)
Through the use of biorefinery is it possible to create biofuels from the extracted sugars and oils of spent coffee grounds (Atabani et al., 2022).

2.3 Midterm: Coffee ground cast

For the midterm I've decided to focus on the odor neutralizing factor of spent coffee ground. I chose this due to there being less research on this quality of the coffee ground, therefore having more range for unutilized potential. Also this specific quality piqued my interest.

From my prior findings in the material exploration of the coffee plaster mixture, I found potential as it being a filler product. Moreover, it was noted that the scent of coffee remained inside the plaster. Due to this observation, I wanted to explore it further to see if the material property of odor neutralization can be adopted by the plaster. Giving the plaster a natural property of deodorization.

In a discussion with my coach Rong-Hao, the idea originated for the use of this plaster in medical casts. Especially the casts that are used for broken body parts. Due to the air-limiting nature of the cast combined with the inability to wash underneath the cast, over time, this will lead to a build-up of odors. Mostly consisting of the odor of dried sweat.

The solution that was explored during the midterm was adding a deodorizing material when creating the cast. This material should absorb the odor inducing particles thus, the built-up of odors will be limited. Prototypes were made to showcase the possibility in the combination of a plaster cast and spent coffee ground. This can be seen in the image.

While the integration of coffee waste into materials was positively received, the main concern was the mold that occurred during my prior testing. The concern is that due to sweating inside the cast, molding could develop. To combat the effect of mold development in my materials it was advised to serialize my work when creating the material. This needs to be explored further. Furthermore, the duration and effectiveness of the odor neutralizing factor was raised during the feedback.

In combining the plaster with spent coffee grounds it's not yet determined how much of the odor neutralizing factor is present in the material.

Concluding from the feedback of the midterm I decided to step away from creating a cast solution with the coffee material. For the next stages, I took to focus on further developing the material by trying to eliminate its defaults. Meaning to focus on the prevention of molding in the material

2.4 Material Testing

For the material to be validated on its effectiveness a group of volunteers will participate in a smelling experience, an A/B test. For this test multiple material samples will be created with different concentrations of spent coffee grounds. Next to this, there will be a control group of the same concentration. This control group is made using charcoal as a substitute for the spent coffee ground. Charcoal is known to have odor-neutralizing properties as well. Before these material samples can be validated, the samples need to be made with the prevention of mold development in mind. Since the molding would affect the validation process and the reliability of the material.

To get a better understanding of how to create a sterile working environment I contacted a microbiologist, who works with sterile testing on a regular basis. He explained there are multiple ways of simulating a sterile working environment from home. First of all, all of the equipment needs to be sterilized beforehand, this includes the materials.

Even though my samples could not be created inside a sterile lab environment, the biologist agreed to sterilize the separate materials to decrease the contamination risk. This includes the collected spent coffee grounds, the plaster, the water, and the charcoal. sterilization was done using an autoclave device. For my work environment, I sterilized all equipment and working surfaces with sanitation alcohol. This was recommended for the wanted results.

The set-up of all equipment can be seen in the picture. Each sample mixture was made and measured with tablespoon measurements. After a day of drying all samples were placed in closed containers to avoid further contamination.

After a couple of days of the drying period, the samples were inspected. The charcoal samples were completely dry and free of molding. The spent coffee ground samples were damp in their containers and starting to show small signs of mold. This is far less than the prior samples made, however still not the wanted result.

Reflecting on the process two changes needed to be made that could create better results. The first change is the closed containers. The test samples were placed in containers to avoid any contamination. However, as explained in Saberian et al. (2021) spent coffee grounds can absorb a large amount of moisture. This causes a need for a longer drying period. To resolve this the samples won't be airlocked in the containers and will be closed off by a barrier of tissues, tissues will work as a filter and obstruct some of the contamination while there will be no restriction for the moisture to escape.

The second change that needs to be made is the measuring process of the materials. In the prior sample-making process, the measuring was executed using tablespoon measurements. Upon further reflecting I came to the conclusion that this could lead to inaccurate results for the comparison of spent coffee ground

and charcoal. Due to the materials having different densities also, this way of measuring has a larger probability for human error. This will be resolved by weighing all materials using scales, the measurements will be taken in grams.

The second set of samples was made implementing the changes as discussed. The new ratios can be seen in the table below. All samples were mixed with 20gr plaster and 12 gr water.

4gr CO2	3gr CO2	2gr CO2
4gr Coffee	3gr Coffee	2gr Coffee

Table 1

After a drying period of three days, the samples were inspected. None of the samples showed any sign of mold development. Thus proving a success as a stable material and making it possible to validate the material properties.

2.5 Validation odor neutralization

To validate the effectiveness of the material the following experiment was created, this was based on a similar study by Huong & Huong Thinh (2019) using coffee for the deodorant properties in an anti-odor treatment for wool. In this study the combination of wool and spent coffee ground was used while in this experiment I will test the combination of plaster and spent coffee ground.

Experiment

The test and control material were made in three concentrations. In preparation for testing, each sample was placed in an airtight jar. In each jar 2 grams of finely chopped onion were placed. The onion is the strongly scented aroma that the samples will need to absorb to test the effectiveness. After 12 hours the onion samples were removed.

Seven volunteers consented to evaluate each sample on its odor level. They were given two minutes to evaluate each sample. During the evaluation, the participants were not allowed to communicate. This is done to avoid any bias. Between each sample, the participants were given a small amount of coffee to smell before moving toward the sample. This is done to cleanse their sense of smell, thus starting each sample under the same conditions. Participants rate the intensity of the sample odors as followed: 1. Not perceptible 2. Perceptible, but not disturbing 3. Disturbing 4. Strongly disturbing 5. Unbearable.

After the evaluation, the participants partake in an interview to get an understanding of their way and view of recycling along with their coffee usage. This will be further discussed in 3.1 user interviews.

	Spent coffee grounds			Charcoal		
	S1	S2	S3	S4	S5	S6
P1	2	3	2	2	1	1
P2	2	1	2	4	3	4
P3	4	4	2	2	3	2
P4	4	3	3	2	2	1
P5	3	2	2	2	1	1
P6	3	2	2	3	2	1
P7	3	2	1	2	2	1
Average	3	2.4	2	2.4	2	1.6

Table 2. Results odor neutralizing

Results

The assessment of the odor neutralizing properties in materials are displayed in table 2. Viewing the results it can be said that both natural substances, coffee and charcoal, have a deodorizing effect.

According to the results from the evaluation, for both substances, the higher the concentration the lesser the amount of smell that is perceived. Charcoal in general scores better on the non-perceptibility of smell.

Discussion

The spent coffee ground seems to be less effective compared to the control group made from charcoal. This could be due to multiple factors. The first simply being that the substance charcoal could be a more effective substance for odor control. The second is that charcoal in itself is an odorless material. The spent coffee ground on the other hand carries a natural aroma. Thus comparing a coffee aroma that absorbed an onion aroma to an odorless material that absorbed the onion aroma. Creating a non-equal comparison.

Because of the reasons mentioned above, what can be said for certain for both sample pools is that a higher concentration leads to better absorption of the onion odor.

Furthermore, it needs to be noted that in these results there seem to be outliers. Predominantly in samples 3, 4, and 6. To say for certain if this is the case the pool of participants needs to be larger. From this data pool, outliers can not be removed. If this experiment is repeated, it is advised for the participant pool to be larger.

From the data gathered it can be said that the created material of spent coffee ground remains to have an odor neutralizing factor. Therefore proving to a certain extent that the odor neutralizing property of coffee is adopted into a new material.

2.6 Conclusion

Coffee being a largely enjoyed beverage is the cause of multiple environmental issues. This is only taking into account the organic waste that is produced in the farming, creating, and drinking of coffee. A major contributor to these issues stems from not handling/disposing of the waste properly.

Currently spent coffee grounds have a lot of unutilized properties that are waste laying in a landfill. Two of these properties were examined in this iteration. First coffee as a filler material, causing less coffee to be placed in landfills and needing less of the original material. Second, coffee has odor neutralizing factors. These properties were combined in a new material containing plaster and spent coffee grounds. From testing the new material it was concluded that the plaster adopted the deodorizing property. The application of this material will be examined in the next iteration.

Iteration 3: Product Creation

3.1 User Interviews

To get a better understanding of how people currently recycle, their opinions, and their obstacles, user interviews were done. In addition, the participants were asked about their own experiences with coffee (see appendix). In this section, the main results from the interviews will be discussed and divided into subjects.

Current use of recycling:
Overall the participants expressed the importance of recycling. It was the common understanding throughout the interviews that recycling should be or already is part of the day to day life. The common denominator of products that all participants recycle are the following materials; paper, plastic, and glass. Other mentioned materials are; green waste (GFT), food containers, metal, fabrics/clothing, and electronics.

Obstacles to recycling:
The most found obstacle was that even though participants expressed their desire to recycle, it was too difficult. This was often due to there being no near recycling facilities located near the participants. It was expressed by participants who did not already collect green waste. They were willing to collect but were not able to. These four participants all mentioned that it was due to them living in city apartments. One even tried to create their own compost bin inside the apartment but was stopped due to the smell and attraction of flies.

Concerns about recycling:
Even though all participants saw the importance of recycling, some of the participants expressed their concern about how recycling is handled. They do not know if the effort they put into recycling is being translated into the use of recycled materials. This made two participants less diligent in their recycling.

Products made from recycled materials:
Six of the seven participants admitted to not paying extra attention in the store to see if a product is made and/or packaged with recycled materials. Although half of the people noted that when/if they saw a product was made from recycled materials it would be the preferred option. Even willing to pay a little extra if the product was comparable to a non-recycled product. Others expressed their concern about greenwashing, thus not knowing if the product is a sustainable option.

Food waste recycling:
Three participants already recycled their food waste in green bins (GFT). None of the participants had prior knowledge or recalled the experience of the creation of products out of recycled food waste. There was a divide in the concerns about using food waste in products. Half of the participants were worried about the durability of the products, while the other had no to little concern and trusted the examination process (e.g. keuringsdienst van waarde). Therefore having no issue with buying products made of food waste.

There was less concern about the use of coffee in products and people were eager to see what that would entail. One concern was raised by two of the participants, that depending on the use of the products, they were worried about the smell of coffee in all products. The example raised was not wanting their dinner plate to smell like coffee when eating pasta.

Coffee usage:
Six of the seven participants drink coffee. Four of these participants drink coffee on a daily basis while the other drink coffee on multiple occasions during the week. All the coffee-drinking participants expressed that they most often drink coffee in their homes. At other times the participants would drink coffee at their workplace or at the university.

Most commonly participants drink their coffee black, only two participants preferred milk in their coffee. Four participants did not recycle/compost their coffee, three of which have no access to composting/green bins.

From these interviews I've concluded that the users see the importance of recycling however when it is made too difficult by accessibility issues, the willingness is less present. Furthermore, due to the unclarity of the destination of the collected waste, the participants are skeptical about the effectiveness. This is also largely due to practices such as greenwashing. Lastly, coffee is mostly consumed at home. This is confirmed by the CBI (2021) stating that only 30% of the consumed coffee occurs out of people's homes.

3.2 Product Ideation

To integrate the user interviews the focus of this chapter is on the unclarity in the destination of waste collection. In this ideation process, I tried to incorporate a clear use of spent coffee grounds into products. Continuing on the previous iteration of the properties that are found in the spent coffee grounds.

Based on the exploration of properties in spent coffee grounds from the previous iteration it is apparent that there are unutilized qualities in this waste. As evident from interviews, recycling can be met with skepticism due to the lack of clarity on where the by-products are incorporated.

With this as a starting point, a new brainstorming session was started. Upon reflection with my peers, it became clear that coffee being a versatile material should be reflected in its process or product.

User scope
Based on the results from the interviews and background research on coffee usage a user scope was made.

The target market is based in the Netherlands, this is due to its proximity and the Netherlands being rated among the top

five coffee-consuming countries worldwide (CBI, 2021). The targeted audience is mainly focused to be young coffee-drinking adults, ages 18 to 34. Young adults are targeted due to them being more likely to be interested or involved in sustainable coffee initiatives compared to an older generation of coffee consumers (Tramper et al., 2020). The survey indicates that the preferred way of consuming coffee is drinking it black, made by either filter coffee or espresso-style coffee. This is chosen due to the ability to collect the spent coffee grounds. In addition filter coffee is the most prepared coffee in the Netherlands, with a share of 32% in total (CBI, 2021). Furthermore, espresso-style machines are mostly used outside of the home.

Product direction

Because of the large current demand for coffee within the user scope, the market continues to grow (Mayson & Williams, 2021). The untapped potential for spent coffee grounds asks for a multi-answer solution. In order to combat the waste created by this growing market demand for coffee consumption.

To show a new potential in the coffee market, I suggest a line of different utilizations that the spent coffee ground has to offer. The utilizations I will be focusing on are the odor neutralizing factor, spent coffee ground as filler material, and fertilizer.

3.3 Product Development

To display the different potentials spent coffee ground has to offer multiple product options are created. These product options show the versatility of the spent coffee ground.

Odor neutralization

As proven in the prior iteration, the combination of spent coffee ground in plaster creates a new material that has its own deodorizing factor. Plaster is material that can be shaped into different forms depending on its intended use. Due to the new addition of a deodorizing factor, multiple new applications could be created. To showcase these qualities simple forms of disks were created

They are small in shape to show portability. Giving users the opportunity to assign it to a place they seem fit. This could be placed inside a fridge, toilet stall, or near the trash cans.

Fertilizer

Due to the high nitrogen content inside the spent coffee ground they can be used in their raw form as a plant fertilizer. To get a better understanding of theproduct application I was allowed to view inside a plant nursery (see .. picture in the kas). Here I saw the process of potting the nursery plants in order for them to develop. Oftentimes a seed is developed inside a small developing plug. These plugs are made from plastic and are oftentimes used only once.

The large number of plastics used in this process are cause for a continuation of plastic by-products. From the nursery, it was noted that using the plastic plugs made for an extra step of removing the plug before the seeded sprout is planted into a larger pot. This is done manually due to it being delicate work. The manual labor creates a larger cost for the nursery with the addition of a possibility for human error. Human error in this process would entail that a plastic plug is kept on

the sprouted plants while repotting, thus obstructing the root growth of the plant in a later process.
Based on the experience inside the nursery and a brainstorm session the following fertilizer application is proposed. A biodegradable planter plug made from the spent coffee ground. The seed that would be developed inside the planter plug would benefit from the addition of nitrogen, thus creating a nutrient-rich environment for the seed to sprout. In addition, due to the plug being made from spent coffee grounds, the planter plug is biodegradable. Thus avoiding the use of plastic in this process.

To create these planter plugs I looked back on the previous iteration on material exploration. There I experimented with creating a leather-like husk made from spent coffee grounds and fruit scraps, apple scraps to be precise. This material is completely compostable and without the use of harmful materials that could interfere with plant growth. Therefore it was decided to explore the coffee husks further to see if they can be applied to the planter plugs.

The coffee husks were recreated to be used for the planter plugs, as shown in …. . Due to the limitations in creating the coffee husks made from the coffee/apple paste, the coffee husks were made in sheets. These sheets were in turn molded into the required plug shapes.

The plugs are now ready to be used to develop seeds into sprouts.

Filler material

Spent coffee grounds as filler material can be used for different applications. A filler material is used to create a higher volume and or structure to an original or existing material. Thus needing less of the original material for the desired use. While keeping the filler material from ending up at a waste facility.

To showcase spent coffee ground as filler material in this project, it was chosen to use it in plaster. To continue on the previous exploration of coffee and plaster.
Plaster is a material that can easily be shaped using the desired mold. To translate the findings on the subject of plant plugs, and the application of fertilizer, the shape chosen is a plant pot. The mold for the pot was DIY'ed from recycled food containers. Due to the large size, compared to earlier samples made with coffee plaster, the drying time was longer than expected. After several days the pot was removed from the mold to let it set further.

It should be noted that in this process, even with the longer drying time, no mold developed on the plaster. From this it was yet again confirmed that the method of sterilizing the process proves to be successful in avoiding unwanted mold.

GroundUp

To abridge the above mentioned solutions and application for spent coffee ground, they are combined as the project GroundUp. GroundUp a way of utilizing the otherwise wasted resource, spent coffee ground. In order to create these products, the spent coffee grounds need to be collected. This, especially in cities, poses difficulties. Looking at the larger cities in the Netherlands, there are not that many options to be able to collect green waste, let alone collect type specific waste, spent coffee grounds.

As it is mentioned above, it was presented on Demoday. Overall the project was received positively. However, the main feedback received was about the relevance in the business aspect of GroundUp. This was found to be lacking. To resolve this a business case will be created to get a deeper understanding of the stakeholders, how to attract the stakeholders, and how revenue will be created.

Iteration 4: Business Case

In previous iterations the qualities and the versatility of spent coffee grounds were shown, this is only one part of combating the waste caused by coffee. For diminishing the problems generated by the consumption of coffee multiple factors are needed.

First of all, the collection of spent coffee grounds. In order for the spent coffee grounds to not end up at the landfill, they need to be collected separately. Second, the creation of products. To utilize the spent coffee grounds they need to be incorporated into new products, thus creating new value through valorization. Third, and perhaps most importantly, creating a business. In order to keep the coffee away from landfills, thus having a positive environmental impact, value needs to be created by the business and for the business.

Business proposal

GroundUp is a company designed to tackle the sustainability issues surrounding the coffee industry. Specifically the organic waste accumulation of spent coffee grounds. Coffee is the second most traded commodity worldwide (Zabaniotou & Kamaterou, 2019; Saberian et al., 2021). This massive coffee market is the cause for an annual accumulation of 2 billion tonnes of organic waste (Jimenez-Zamora et al., 2015). Largely consisting of spent coffee grounds. The residue that is left behind after the brewing process of a cup of coffee. This residue is currently often discarded in a landfill, causing the release of toxins (Atabani et al., 2022; Kanniah, 2020). Aside from the environmental impact, spent coffee grounds have ample qualities that are currently wasted.

To combat this GroudUp proposes two

main factors, a service and product sale. The service consists of a coffee waste collection point, this will be in collaboration with coffee shops. Making the coffee shops partners as well as customers. Thus a vital stakeholder. They provide the location for consumer coffee drinkers to dispose of their spent coffee grounds. While benefiting from a sustainable waste collection service. In due turn it created extra foot traffic of coffee drinkers inside the coffee shops.

The product sale consists of products created from the collected spent coffee ground. The products that are made utilize the otherwise wasted properties of spent coffee grounds. The products range from; The odor neutralizing disks, using the deodorizing quality of coffee, planter plugs, biodegradable husks made from coffee meant for sprouting plant seeds. The seeds will benefit from nutrients given by the coffee, creating a fertilizing factor through to plant pots made from the combination of coffee and plaster. Coffee is used as a filler product in the plaster, thus needing less material while creating an aesthetic effect. Therefore creating two revenue streams.

4.1 Business Model

To further examine the business potential and validate the proposal a business model is made. This can be seen in the following canvas.

Cost & Revenue

Here some costs are some estimations of the cost and revenues that can be accumulated in a year. The cost and potential revenue were calculated using analogous estimating. These costs entail the product developing costs, facility costs, distributing and collection costs. To have a better appraisal of the facility, distribution, and collection cost, for this estimation the city of Eindhoven was used as a base. With three stakeholder coffee shops distributed in the city.

The total cost and revenue estimates:

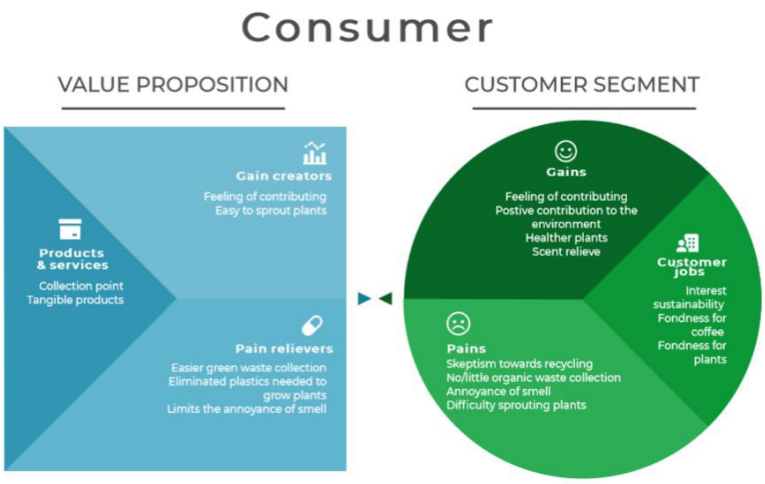
- Annual developing/manufacturing cost: €20.531,25
- Annual collection costs: €720,-
- Annual facility costs: €15.600,-
- Annual product revenue: €65.700,-
- Annual service revenue: €1.150,2

Based on these estimations there will be a yearly profit of €29.998,95.

The biggest yearly expense in my estimations are the labor wages. In manufacturing cost alone it is calculated to be more than 75%. Meaning that if the manufacturing could be automated it would be a well calculated business investment. Even though these estimations show potential of GroundUp being profitable, it is recommended that a large sum of these initial profits are invested back into the business. For GroundUp to be able to expand to other regions of the Netherlands, thus creating a larger environmental impact.

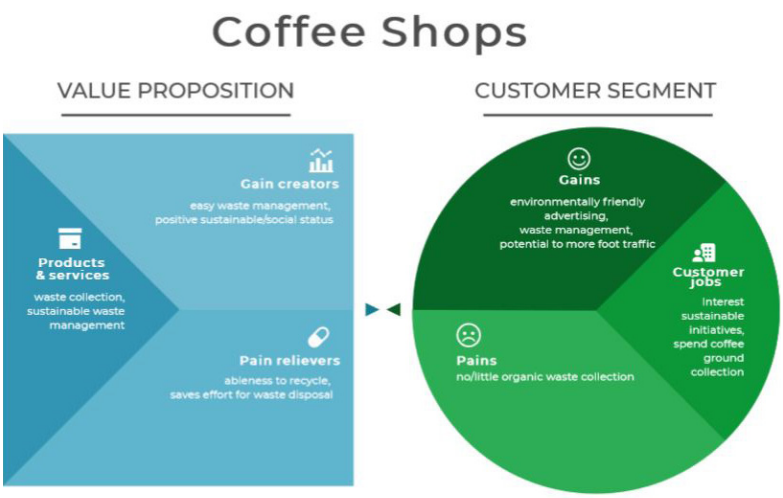
Value Proposition & Customer Segment

In the business model being a multi sided platform is incorporated. Meaning it has a service to other businesses (e.g. coffee shops) and a product value to consumers. Therefore, separate value proposition canvassen were constructed. These can be seen down below.



Consumer

The consumer based value is a combination of the application of the products and the feeling of contributing to a green initiative. The skepticism of the consumer is met by seeing a direct result of their recycling. Meaning the product reflects their recycling/sustainable process.



Coffee shops

The coffee shops based value mainly consists of easy waste disposal for the owners of the coffee shops, the cost of disposal is relatively cheap making it cost-efficient. Furthermore, by partaking in a green initiative the coffee shops create a positive status associated with them.

4.2 Final Design

To summarize, GroundUp was created for the intention of limiting the current impact spent coffee ground has on the environment. This is done with the use of a spent coffee ground collection service. What causes the spent coffee ground is being kept away from the landfill or being incinerated. In addition to the collection of spent coffee grounds, GroundUp is responsible for the creation of new products by recycling the organic waste. Thus creating new value from an otherwise wasted material.

GroundUp creates a collaboration with local or chain coffee shops. Making for a beneficial partnership while lowering the footprint of the popular coffee beverage.

Discussion

GroundUp is created for the goal of making a more environmentally friendly alternative to having spent coffee grounds be dumped on a landfill. Thus avoiding access waste accumulation and causing potential toxic effects. For this to be successful the partnership with coffee shops is key. The success and failure will be in direct link to this partnership. This is a weakness in the business model. What will be especially critical during the start-up of GroundUp.

Due to this, in the cost structure of GroundUp, the waste collection service is priced relatively low compared to competition inside the market. Another reason for the lower revenue on the waste collection service, is that by collection a “free” material is assembled. Making it possible to create more products to sell to the consumers.

Although the calculations for revenue was made based on existing competitor prices, no user validation research was done of the pricing value of what the user would be willing to spend. For future consideration an user evaluation needs to be executed in order to get a more realistic pricing. Meaning the revenue could rise or decent based on the evaluations.

Another future consideration is that the use of coffee pads and cups are currently left out of the spent coffee ground collection process. As mentioned in the user scope, filter coffee is the most prepared for coffee consumption. However, coffee pads are second as preparation method. This was chosen to not be included in the collection process due to the extra layers of packaging surrounding the coffee. This creates a barrier and makes it difficult to recycle the spent coffee grounds. If GroundUp is to further develop in the avoidance of coffee grounds in landfills, It will need to integrate a recycling process of coffee pads and cups.

Reflection

At the start of the semester I was very excited to finally begin my Final Bachelor's Project. To be completely honest these last two years of Covid-19 have been a heavy burden on my mental health. I was mentally stuck and could not get myself out of it. By beginning my FBP I felt that I could be moving forward. The restrictions surrounding Covid-19 were lifted and I was able to go back to university again.

My first challenge in my FBP was choices. Even though I looked forward to having the chance to create a project that is completely aligned with my own interests and visions, there were limitations in doing a project alone that I did not foresee. In group projects often compromises need to be made to keep moving forward as a team. In doing a project by yourself these compromises are not a factor. However, this makes it difficult to narrow down the direction for a project subject. This made me realize the importance and the efficiency group discussions can offer. For this project, I had to force myself in making all the decisions. This proved to be difficult at times. What seemed to work best for me was creating my own deadlines for the needed decisions.

Lacking external pressure in this project, while still healing mentally, I had trouble motivating myself at times. I was at a loss of focus and became unable to work. This became a major stress point for me. To the point of becoming physically ill due to stress. This in turn, led me to often not be able to come to the university physically for squad meetings. Trying to follow these online while almost everybody is present physically proved to be tough at times. Hybrid meetings were often not successful.

Upon later reflection and discussions with the study advisor, it became apparent to me why I had become so mentally exhausted from attending the squad meetings. I am autistic, I have known this for years, however, I was always forced to cope, thus not allowing myself to reflect on the struggles I encountered. During Covid-19, social interactions were very limited, high-pressure social situations such as large groups especially. I did not know it at the time, but I had trouble adjusting to the physical classroom. Causing unforeseen problems for me in combination with the stress I was experiencing. Making it hard to organize myself.

Due to this combined struggle, a necessary extension was given to me. Receiving the extension gave me the focus for working towards demo day. I hoped that this focus would continue and allow me to take on more explorations. However, after demo day I took a major setback, mentally and physically I was drained. Making me revise my earlier plans and downscale. It saddens me to do so but it was the necessary action.

One of my goals starting this project was to apply the knowledge of business and entrepreneurship I gained in previous courses. In my past projects, I had not been given the opportunity to apply this yet. This was mostly applied in my last iteration using the business case. This was regrettably also the part I had to downscale as explained earlier. Despite this being the case I felt I had taken advantage of my knowledge in the process of making the business proposal and estimating the cost structure. Giving myself a better practical understanding in the theoretical knowledge I had prior.

Further, I wanted to develop in the crea-

tion of sustainable design, I had a predominantly circular design in mind. However, while exploring the food waste-oriented problems I soon realized I had to explore it from a different angle. Food and coffee being unique materials, I decided to focus on the material first and later examine the possible applications. This early pivot I believe was the right decision in order to get a better understanding of the problems and solutions surrounding coffee waste.

All in all, this project came with its own ups and down, this caused me to develop a great deal in my professional and personal growth. I am glad to have taken part in a project focusing on sustainable development for my FBP and hope to continue on in similar project cases.

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Food Waste Log

This log is filled in as a first-person perspective on consumer food waste.

Day 1

When?	What?	How is it disposed of?
09:11	Apple core	In the trash bin
09:16	Coffee grounds	In the trash bin
13:01	Cheese crust	In the trash bin
	Tomato inside	In the trash bin
18:55	Onion peel	In the trash bin
	Garlic peel	In the trash bin
	Parmesan crust	Used in the sauce as a seasoning, after disposed of in trash
	Leftover pasta sauce	Freeze for later use

Day 2

When?	What?	How is it disposed of?
8:30	Coffee grounds	In the trash bin
9:15	Coffee grounds	In the trash bin
10:35	Grape twigs	In the trash bin
18:30	Onion peel	In the trash bin
	Garlic peel	In the trash bin
	Parika seeds/inside	In the trash bin
	Chicken scrabs (fat)	In the trash bin

Day 3

When?	What?	How is it disposed of?
8:15	Spent teabag	In the trash bin
11:00	Banana peel	In the trash bin
14:00	Parika seeds/inside	In the trash bin
19:30	Cucumber core	In the trash bin
	Tomato core	In the trash bin
	avocado seed and peel	In the trash bin
	garlic skins	In the trash bin

Day 4

When?	What?	How is it disposed of?
7:40	Coffee grounds	In the trash bin
8:20	Coffee grounds	In the trash bin
10:45	Grape twigs	In the bushes
15:00	Apple core	In the trash bin
18:15	Carrot tops	In the trash bin
	cabbage core and outer leaves	In the trash bin
20:15	Coffee grounds	In the trash bin
21:30	Spent teabag	In the trash bin

Interview questions:

1. How do you feel about recycling?
2. What do you recycle?
3. When buying products do you pay attention if the product/packaging is made from recycled materials?
4. Do you recycle food waste?
    a. If yes, how?
    b. if not, why?
5. How do you feel about recycling food waste into products?
    a. any concerns?
6. What if the food waste recycled was coffee grounds?
    a. any concerns?
    b. how do you envision this?
7. Do you drink coffee?
    a. if yes
        i. How often do you drink coffee?
        ii. How do you get/make your coffee?
        iii. What is your favorite way to drink coffee?
        iv. What do you do with the trash you make during the coffee process?
        v. Is this different compared to other food trash?
    b. if no
        i. What do you like to drink?
        ii. What do you do with the trash you make while creating your food/drinks?