

Report

Mushroom farm



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Acknowledgement

Glossary

Abbreviation	Description
ANIPLA	Associação Nacional da Indústria para a proteção das Plantas
CAGR	Compound annual growth rate
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus

1 Introduction

1.1 Presentation

The team is made up of 6 interdisciplinary students from 6 different nationalities. The team has come together to be part of the European Project semester (EPS) in the spring of 2019 at Instituto Superior de Engenharia do Porto (ISEP). Over 5 months (1 semester) the team is going to use each other's knowledge from various backgrounds and strengths to work on creating a sustainable mushroom farm using coffee waste. This highly motivated and passionate is shown in Figure 1.



Figure 1: Our lovely team

1.2 Motivation

The team's motivation behind choosing the project to build a mushroom farm using coffee waste was that although everyone comes from interdisciplinary background, none of the team members had

directly worked with food production. Everyone in the team could agree that the food industry has quite destructive processes and so everyone was motivated to create a sustainable food system which encompasses sustainable social, environmental and economical practices to encourage environmentally friendly practices. The whole team was directly interested in the delicate process used to cultivate mushrooms and how it could be optimised. The idea allowed everyone to use their specific discipline/skills in a totally unique and new situation broadening their understanding in not only their field but how their field can be applied to new industries. The team also took this opportunity to develop their skills in project management, soft skills and ability to work as a team.

1.3 Problem

Coffee is a massive industry, with more and more people consuming coffee, the negative environmental effects from the industry keep growing. When a coffee is made only less than 1 % of the biomass ends up in the cup. Think about this for a while... There are more than 9 Billion kg of coffee beans per year! A huge amount of energy and resources go into producing and shipping coffee beans around the world however all the value is placed on the liquid extraction of their flavour. But the problem here is that 99 % of the biomass from the coffee is wasted [1]. This huge amount of coffee waste is still full of nutrients which are a very good growing medium for Oyster mushrooms to grow in. The waste coffee is full of cellulose which Oyster mushrooms need to grow. The wonderful thing about mushrooms, is that they are nature's natural recyclers. For example, when trees fall in a forest, it is the mushrooms which break down these complex molecules in the wood and recycle them back into food chain for bacteria, insects and other types of fungi to return back to the soil to be consumed. Mushrooms play a crucial role in the cycling of nutrients and their ability to do this makes them perfect for recycling a wide range of organic waste streams. Oyster mushrooms in particular, are very versatile and have shown to grow on over 200 different agricultural waste materials. [2]

1.4 Objectives

The main objective is to develop a sustainable service by which waste coffee is collected and used as a growing medium for oyster mushrooms. Waste from another industry is being taken and utilised to produce food. This is sustainable by definition. A system will be designed to make the process as sustainable/efficient as possible. This will be done by developing a device which allows the monitoring and optimisation of the growing environment for mushrooms to thrive and grow in abundance from waste. This device will allow the cultivation of Oyster mushrooms on a large scale in order to be sold to consumers (restaurants, supermarkets etc.) however the device will also be able to be modified in order to allow consumers to purchase the device and cultivate mushrooms on a smaller scale at home. This can be achieved through a modular design. The aim of the overall image and values of the company is to promote sustainable food production and to connect people back to the food they eat. This is to stimulate a more environmentally friendly mindset. This will be aimed at a local market whereby local economy is supported by sourcing, producing and selling within the local market. Surrounding the whole project the team aims to develop multidisciplinary skills as well as soft skills such as project management and communication skills.

1.5 Requirements

The project has the following requirements:

1. Automatic monitoring and control of the chamber conditions
2. The medium or small scale of the device
3. Usage of low-cost hardware solutions (Not exceed the budget of 100 €)
4. Usage of the open source software
5. Adaptation of the International System of Units (NIST International Guide for the use of the International System of Units)
6. Comply with the following EU Directives:
 - Machine Directive (2006/42/CE 2006-05-17) [3]
 - Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15) [4]
 - Low Voltage Directive (2014/35/EU 2016-04-20) [5]
 - Radio Equipment Directive (2014/53/EU 2014-04-16) [6]
 - Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27) [7]

1.6 Functional Tests

To ensure the proper functioning of the prototype, the sets of tests presented in table 1 will be performed:

Table 1: Tests

Test cultivation Process	Sensors/actuator Test	Hardware Testing	Software Testing	Material analysis
Sterilization of Coffee waste	Humidity control	Power Supply Circuit Test	Sensor Functionality	Material Simulation
Incubation period	Temperature Control	Sensor Functionality	Actuator Functionality	FEA Analysis
Fruiting Period	Airflow control	Actuator Functionality	Integration of sensors	Chemical/Aqueous resistant
Harvesting Process	Luminosity control		Full system Functionality Simulation	
Waste Management				

1.7 Project Planning

The project is coordinated according to agile project management in terms of scrum methodology. Scrum is an agile project management methodology or framework used widely for software development projects with the aim of delivering new software capability every two or four weeks. The approach articulates a set of values and principles to guide decisions on how to develop higher-quality software faster. Nowadays, not only is it used for software development but also it has spread to other projects such as IT and marketing where the speed of work is high in the presence of complexity and ambiguity [Collabnet Versionone, 2019].

The main advantages of this concept are:

- Higher productivity

- Better-quality products
- Better team dynamics
- Reduced time to market
- Improved customer satisfaction

The Scrum framework is shown in Figure 2:



Figure 2: The Scrum Framework

<http://www.pmoinformatica.com/2018/01/certificacion-scrum-master-profesional.html>

1.8 Report Structure

The project is structured in eight different chapters as shown in Table 2.

Table 2: Report Structure Table

Task	Title	Description
1	Introduction	General introduction of the team, the motivation and the objectives of the project
2	State of the Art	Research of existing solutions and products on the market in term of scientific aspects
3	Project management	Documentation of the progress in accordance with the concept of the agile management method SCRUM
4	Marketing plan	The brief description of the market analysis, on what is built a marketing strategy consisting set of actions to implement it
5	Eco-efficiency measures for Sustainability	Set of necessary components such as design, tests, and calculations in order to make the project sustainable.
6	Ethical and Deontological Concerns	Analysis of the ethical challenges, limitations and their possible solutions
7	Project Development	The architecture, components and the functional tests of the made prototype
8	Conclusion	Summary of the results and possible future development

2 State of the Art

2.1 Introduction

In the State of the art, the natural growing process of growing mushroom is going to be discussed, along with the different existing solutions, for industrial and individual purposes.

The state of the art refers to the highest level of general development, as of a device, technique, or scientific field achieved at a particular time. This is done to get ideas and solutions that could be added into the product or business plan. The cultivation process will be investigated in a lot of detail to gain a much richer understanding of the process to see if any areas can be optimized or simplified to allow people to grow their own mushrooms as well as producing them on a more industrial scale.

By gaining a deeper understanding of not only the cultivation process but also the market allows

details analysis of potential gaps in the market leading to a particular niche to be capitalized on.

A mushroom farms primary goal is to produce a consistent yield of mushrooms to be sold on the market. The goal of this report is to investigate the feasibility of creating a business surrounded by the idea of growing mushrooms using coffee waste. The output of the business needs to be investigate through market research however the vision of the business is clear. To connect people back to their food through sustainable food production. This will either be done by creating a sustainable mushroom farm that supports the local economy, local environment and local people, or by creating a service that allows people to learn and grown their own mushrooms at home, thereby reconnecting them with the food they eat and how it is produced.

2.2 Presentation of Oyster mushroom and its growing process

2.2.1 Oyster Mushroom (*Pleurotus Ostreatus*)

Because the business is based around growing mushrooms in coffee waste, the mushroom best suited to do this is the Oyster mushroom. Coffee has loads of cellulose in it which is essential for the cultivation of Oyster Mushrooms. The common name Oyster refers to multiple species of mushrooms including *Pleurotus pulmonarius*, *Pleurotus salmonostraminus*, *Pleurotus djamor*, *Pleurotus citrinopileatus*, *Pleurotus ostreatus*, *Hypsizigus ulmarius*, and others. These mushrooms come in a range of colours, size and texture. Oyster mushrooms can come in pink, blue, blue, brown and white. This allows small scale growers to cultivate 4 or 5 different products with growing oyster mushrooms. Oyster mushrooms are native to North-eastern US. Most of the strains of oyster mushrooms can be cultivated using the same system and growing process, all that differs is the spawn used, meaning only one method of cultivation needs to be mastered in order to produce an attractive assortment of different oyster mushrooms.



Figure 3: Types of Oyster Mushrooms

2.2.2 Mushroom growing process

Oyster mushrooms are basidiomycetes, referring to their method of sexual reproduction. The gills on an oyster mushroom contain basidia (microscopic structure). Attached to the basidia are 4 haploid spores which are released into the air at maturity. These spores germinate into mycelium. The mycelium grows through its food, in this case coffee and eventually fruits a mushroom providing the growing conditions are suitable. Oyster mushrooms are known for their heavy spore count and therefore routine cleaning in the fruiting room/environment is crucial. The goal of the mushroom is to provide a platform for sexual reproduction and release of the spores. Humans, insects and animals are part of the chain which spread the spore of the mushroom. [9] Mycelium continually breaks down food using an enzyme. These chemical enzymes contain antimicrobial compounds which create a protective barrier around the mycelial network. Fungi digests externally and then absorbs nutrients that have been broken down into its body. These enzymes break down food like lignin and cellulose (both found in coffee) into simple sugars which are used for continued mycelial growth. This is known as the colonization of mycelium or the incubation period after inoculation has occurred. [10] It is crucial to have a solid understanding of mycelium because this is what mushrooms fruit from. Without healthy cultivation of mycelium, fruiting of the mushrooms will not occur. A mushroom farm firstly needs to cultivate mycelium and then through the maintenance of the right conditions (high moisture, high oxygen and the right temperature) will cause mushrooms to grow. Paying close attention to the

health and growth of mycelium will help to achieve bigger yields. Mycelium needs to be cultured in a petri dish, this single petri dish is the starting point to produce large quantities of mushrooms. Different strains can be cultured to meet the needs of the growing. After then mycelium has been fully colonized and the right conditions are met for fruiting to occur, mushrooms will mature within a week. At this point they are ready for harvesting. Each cake of block of colonized mycelium will produce between 3 to 4 flushes of mushrooms. After the 3rd or 4th flush of mushrooms the remaining mycelium can be recycled by adding more substrate (food) and allowing it to colonize again so fruiting can occur. The Consistency of all these methods is the key to success. [11]

Growing Mushrooms in coffee.

Mushrooms are notoriously hard to grow because of inconsistent results. This is partly due to the mass production of low-quality grow kits which give unreliable results. Even in the wild mushroom's growth is very unpredictable. However, by using the correct knowledge and relatively simple techniques it is very possible to cultivate mushrooms on both an industrial and home scale. Similar to the fruits produced by a tree, mushrooms are the reproductive fruits of a dense rootlike network of cells known as mycelium. When mycelium runs out or it's put under some type of environmental stress it switches into survival mode and produces mushrooms in order to release its spores into the wind to find a better place to live. Lucky for us it is possible to recreate and manage the life cycle in order to cultivate good crops of edible mushrooms. Mushroom farming heavily relies on very strict growing conditions and minimising competition through pasteurisation [12]. However, this can cost quite a lot for someone who wants to grow at home. One of the aims is to make it as cheap and rewarding as possible. For this reason, oyster mushrooms are great place to start as they are very resilient and can grow in many types of agricultural waste. The most common materials used to grow oyster are freshly cut hardwood logs or straw. Growing on logs can be quite difficult and can take several years before your first harvest. Growing on straw requires pasteurization to kill off any microorganisms that will compete with mycelium. Growing in coffee has quite a big advantage as it has already been pasteurized by the brewing process meaning it is ready for inoculation, skipping out the pasteurization step. Not to mention but used coffee grounds are a massive wasted resource as they are still full of nutrients which oyster mushrooms love to grow on.

Inoculating

Firstly the mushroom spawn needs to be ordered. You will have greater levels of success if you use high spawn to coffee grounds ratio. To start 500g of oyster mushroom spawn to each 2.5kg of used coffee grounds. [13] Inoculation can be done in filter bags or buckets to provide perfect growing environment and to prevent chances of contamination. Bags will have a filter and containers will have small holes.



Figure 4: Stages of inoculation

Coffee collection

In order to skip out pasteurization step, the waste coffee needs to be fresh that day and therefore a service will be created to collect fresh coffee waste. Once the coffee waste is collected fresh, with very sterile conditions the coffee has to be mixed with the mushroom spawn and then added into the cultivation bag/container. Ensure there are small air holes if a container is being used instead of a filter bag.

Spawn Run

Place container in a warm (18-25) and dark place. During the next 3 weeks the spawn will come to life and colonize across the coffee grounds, turning the mixture white. [14]

Fruiting

After about 3 to 4 weeks the whole container of coffee and spawn mix should be completely white. If you see any other colours such as green or black, then this is a competitor mold and needs to be removed. Salt can be used to kill it off without compromising the mycelium. This is why hygiene is so crucial. If you have achieved a nice white container then the mycelium is ready to enter the fruiting process by which you get mushrooms. Place the container in a pot with plenty of fresh air and a little light. Mushrooms love humid conditions so it is important to spray the mushrooms so they dont dry out. [15] After a week or so you will see mushroom pins start to develop. Over the next 5/7 days the mushrooms will double in size every day. When the edges of the cap start turning upwards it is time to harvest. Cut the mushrooms at the base and be sure to remove the whole mushroom. You will typically get 3 or 4 flushes. The remaining mycelium can be used as spawn for the next grow.


2.3 Existing solutions for individuals


Mushroom kit

A substrate is already inoculated with mycelium and wrapped into plastic. Wrap is then placed inside the box, which is relatively small and allows to grow mushrooms anywhere in a home. Consumer has to cut an opening into the package and sprinkle it with water on a daily basis. After some time mushrooms will start to grow. After harvesting the process can be repeated twice.

Examples of existing mushroom grow kits are shown in Table 3.

Table 3: Mushroom kits available in Portugal

Name	Picture	Product	Mushroom type	Country of origin	Pricing
Resetea	 <p>[Resetea, 2019]</p>	mushroom growing kit	Oyster	Spain	19.90 €

Name	Picture	Product	Mushroom type	Country of origin	Pricing
CogusBox	 <p data-bbox="288 607 695 640">[Cogusbox, 2019]</p>	mushroom growing kit	Oyster	Portugal	10.00 €
Kit Zás	 <p data-bbox="288 1032 695 1084">[Reforma Agraria, 2019]</p>	mushroom growing kit	Oyster	Portugal	9.97 €
Siro	 <p data-bbox="288 1352 695 1402">[Siro, 2019]</p>	mushroom growing kit	Oyster	Portugal	8.83 €

Strengths of grow kits:

- Easy to use
- Customers gain knowledge through the process
- Mushrooms are fresh
- Grow kit is easily recyclable

Weaknesses of grow kits:

- They are not designed for sustained cultivation of mushroom
- Only around 3 small flushes can be harvested

2.4 Existing industrial solutions

Aromas & Boletos

A company that focuses on enhancement of sustainable and ecological production of wild and exotic mushrooms. Products and services for mushroom cultivation are developed and marketed. In laboratory modern techniques are used to produce mycelium and substrate. Array of products includes mushroom spawn, grow kits, lab supplies, mushroom production equipment and gourmet mushrooms. In the area of research, innovation and development Aromas & Boletos strives to innovate the production of mushrooms. They also do workshops for producers and aficionados, showcookings, tastings and other activities in nature.

Cogumelos Cultivados Lda.

A company that is specialized in the production, commercialization and distribution of exotic mushrooms. All the production is done in biological way, focusing only on the national market. Sales are made directly to the customers (restaurants & hotels, shops and markets, some supermarket chains. Mission is to be an asset in the Portuguese food market and to offer high quality biological products at affordable prices.

Floresta Viva

Floresta Viva is responsible for the appearance of new producers, through specialized training for the activity with participants from all over Portugal and the Islands, Spain, India and France. The company is committed to being valid partner of the producers, to be an active part in the propagation of the consumption of biological products of high quality control. Their services include monitoring and technical support for mushroom producers, workshops on the production of mushrooms, commercialization of mushroom of different species. Other services are production and distribution of inoculated wood, as well as commercialization of specific machines and tools for shiitake trunk production.

2.5 Conclusion

Mushrooms grow in wild and can be grown on both a domestic and an industrial scale. While farming is nothing new, people are demanding more sustainable foods. People not only want healthy food but want to know that it has been cultivated in a sustainable manner and is not having a negative effect on the environment. People are forced to pay slightly for organic and healthy produce and this is why more and more people are growing their own food at home. There are so many benefits of growing at home. Firstly you almost eliminate the distance between the farm and your plate significantly lowers the carbon footprint of the food and guarantees freshness. Cultivating food at home can be educational and can connect people back to the food they eat. Many people do not have access to growing spaces and are sometimes unable to grow at home, but this is what makes growing mushrooms so great. Growing mushrooms does not require a lot of space and can easily be done inside. Domestic cultivation of fungi has been popularized by grow kits, they are easy to use, take little space and after using are easily recyclable, however, there is a major disadvantage, these kits only produce three flushes and are not normally very big. After this a new kit has to be bought or can be re-cultivated but normally can be quite time consuming and requires some specialized equipment, which can be costly for home growers. Cultivating mycelium can be difficult at home because it needs very sterile conditions. People want something that allows them to cultivate mushrooms in a sustainable way but does not require excessive effort or money. A potential solution could be to establish a service that collects fresh coffee waste and inoculates it with mushroom spawn, people would be able to buy cultivated mycelium in coffee waste allowing them to grow mushrooms on a decent scale. Remaining process will be relatively easy. The company, could supply customers with a monitoring device to make growing as simple as possible, as well as providing all the resources and

information needed. Company could also provide courses to teach people about cultivating mushrooms and sustainable foods. Other option could be to build a mushroom farm by which we provide consumers and restaurants with fresh organic mushrooms grown from coffee waste. As there are already existing farms, which have strong position in the market, it would be extremely difficult for an EPS team to compete with established competitors. The Team decided somewhat to combine the two ideas and build a device, while also providing service mentioned above. Service would also include collecting coffee waste.

3 Project Management

3.1 Scope

The first step of successful project management is the creation of scope in order to define and organize the work that has to be executed by the project team. The best idea is to use a simple hierarchical decomposed structure of all tasks and deliverables which are essential to accomplish the final project outcome. One of the widely use structures is a work breakdown structure (WBS), which visually divides the scope into sections, where each of them provides further definition and detail. In figure 5: it is presented brief WBS structure of mushroom farm project.



Figure 5: Work Breakdown Structure (WBS)

3.2 Time

After making scope second step of planning is managing work time. The project is coordinated according to agile project management in terms of scrum methodology but is always better to prepare general overview with milestones and phases in the project, that is why the Gantt chart has been created. The Gantt chart is divided into phases based on project scope. The chart is a more classical tool for monitoring the course of events and tasks completion, but it could be helpful in terms of monitoring and preparing sprint backlog. The Gantt chart of mushroom farm project is shown in Figure 6:

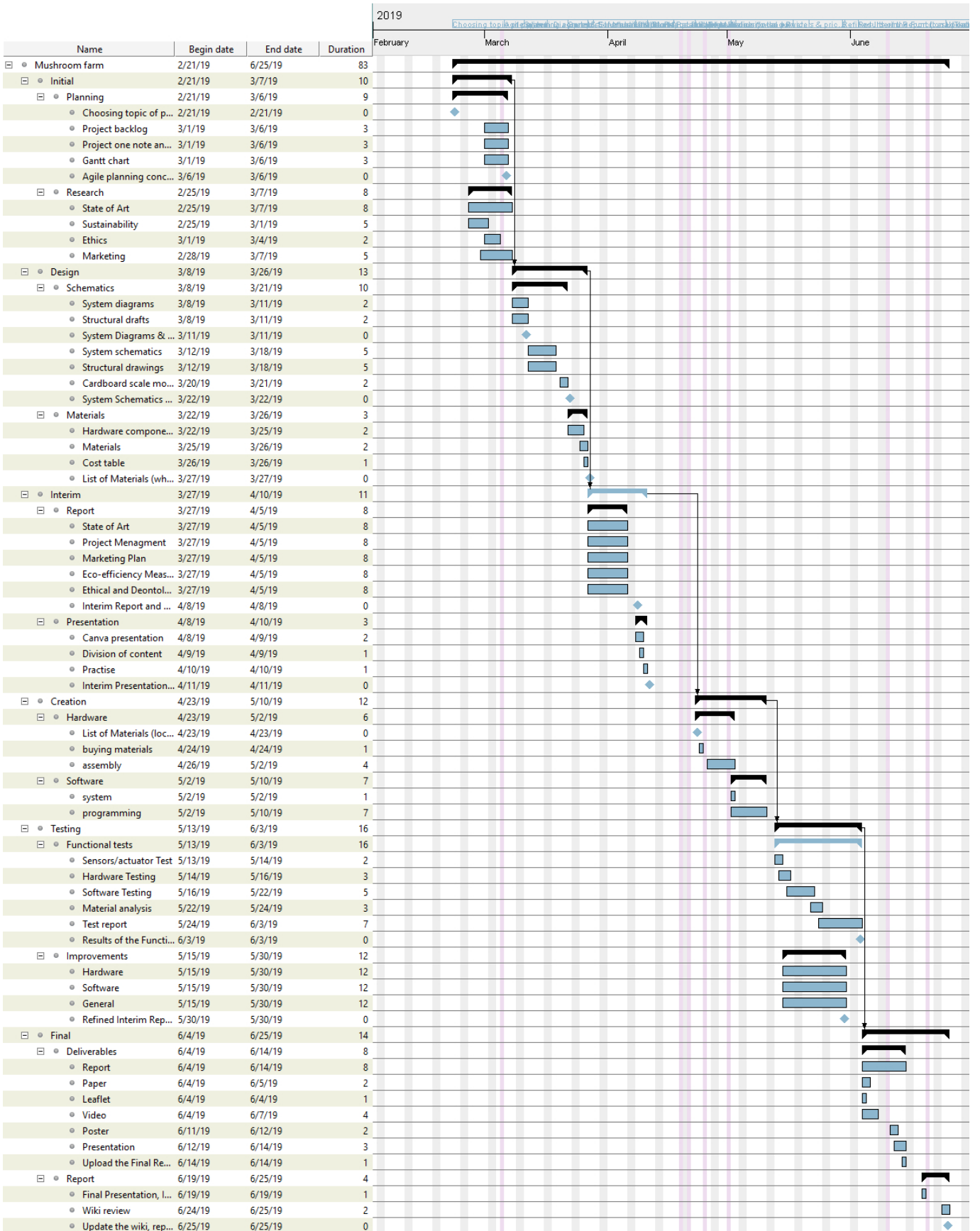


Figure 6: The Gantt Chart

3.3 Cost



Component	Quantity	Price (€)
Oyster Mushroom Spawn	1	~10
Breadboard	1	6
Resistor (10 kΩ)	1	0.05
LED Multicolor	1	0.14
Microcontroler	1	24.90
Pop-up Garden Bag (spring)	1	6
Bucket	3	-
Sensor		
Temperature and Humidity	1	12.30
Material		
PVC Transparent Fabric	1 m ²	~3
Zipper	2	~4
Sewing thread	1	~2
Scratch	1m	5
Fan	2	-
Total		~73.39

3.4 Quality

As waste to Fungi is a business based around food production, quality has a very important role to play as the final product will be consumed. When it comes to food there are certain health regulations that need to be met.

Food quality: To minimize the risk of serious health consequence or even death from consumption of contaminated produce, the Food and Drug Administration (FDA) have established a science-based minimum standard for safe growing conditions, harvesting, packing and holding of produce for fruits and vegetables grown for human consumption. FDA is proposing these standards of the FDA Food Modernization Act (FSMA). [20]

Usage Quality: Before going to market the grow kits and surrounding procedures need to be functionally tested and optimized to ensure high-quality yields. The benefits of growing at home must practice. subsidize the benefits from buying directly from supermarkets. The procedure must guarantee freshness, cost-effective yields and simplicity in the cultivation process. Quality of procedure will be monitored with sensors to ensure the highest quality of growth is achieved.

Service Quality: Service quality surrounding the sale of the grow kits is crucial. Besides providing information for the maintenance of the grow kit at home the business intends to provide a coffee collection service. Business must ensure that there is good communication between suppliers of coffee waste and ensure the proper care and treatment of waste coffee is conducted to avoid any contamination before the cultivation process can begin. The business aim to reconnect people back to the food they eat by supplying educational workshops and information around the idea of cultivating mushrooms and circular economy. Quality of information and workshops must be of high quality in order to spread awareness of safe and good

3.5 People

Responsibility Assignment Matrix is used to identify roles of members in a project team. Matrix is a table that provides an overview of what tasks should be done by whom, while also pointing out responsible person for each task [21]. Our task allocation is shown in Table 4.

Description of symbols used in a table:

- R = Responsible (Person who is mainly working on the assigned task and bears responsibility of completing it)
- P = Participant (Person who has the supporting role in assigned task)
- A = Accountable (The one who ensures that prerequisites of the task are met and who delegates the work to those responsible)
- C = Consultant (Subject matter experts, whose opinions are sought) [22]

Table 4: Responsibility Assignment Matrix

Task/People	Eren	Alex	Julia	Julien	Maike	Ronald	Supervisors
Task identification and allocation			R				A,C
Gantt chart			R				A,C
Blackbox diagram	P					R	A,C
Technical research	P	P				P	A,C
Market research, existing products	P					R	A,C
Initial budget planning						R	A,C
Specific plan			R				A,C
Business plan			R				A,C
Final schemes, diagrams	R					P	A,C
List of materials	P			P		P	A,C
Interim presentation	P	P	P	P	P	P	A,C
Interim report	P	P	P	P	P	P	A,C
Prototype construction hardware	P			P		R	A,C
Prototype construction software	R					P	A,C
Prototype assembly	P	P		P		P	A,C
Prototype functional tests	P	P	P	P	P	P	A,C
Final report	P	P	P	P	P	P	A,C
Video					R		A,C
Poster		R	P				A,C
Manual							A,C

3.7 Communications

Such a multidisciplinary and diverse project as this one would be impossible without good communication. It is necessary both to ensure that all members have the opportunity to express their convictions, thereby increasing positive discussions and diversity of opinions, or to ensure that problems that arise are dealt with appropriately. On the other hand, poor communication can worsen time management, deteriorate the team's relationship among many other problems. Communication is one of the pillars of a good project.

In order to promote good communication in the team, a policy of transparency and honesty has been adopted that allows each member to express their opinion in a judgment-free manner, but subject to constructive criticism, so no problem is left under the rag and the discussion of ideas is encouraged.

In terms of direct communication (in person), meetings are held every day to find out the progress made so far, as well as weekly meetings where a situation is made, and a reassessment to the team's planning and objectives. Moreover, on Thursday of each week, a meeting with supervisor is organized that allows the Team to have an external opinion, to improve research, find new solutions and better organize.

As direct communication is not always possible, alternative communication channels have been created in social networks where it is possible to maintain contact, share documents or any other type of relevant information to the project. The great disadvantage of these means is that compared to direct communication, it is more difficult to ensure that the messages are not being misunderstood, so as to mitigate that effect was agreed between the team that very important matters relating the project would only be discussed in person. The great advantage of these means of communication is that they are easy to reach, very practical and allow the contact to be maintained even when the team is far away.

The main of alternative communication channels used are:

1. Facebook Messenger
2. Whatsapp
3. Google Drive
4. Gmail

The communication matrix is displayed in Table 5 .

Table 5: Communication matrix

What	Why	Who	When	To whom
Deliverables	Development of the project	Team member in charge of the task	On the deadlines	Supervisors and the Team
Daily Stand-ups	Have an overview of what each group member has done so far, what were the biggest difficulties, and what is going as planned, as well as implement strategies to solve the problems faced.	The Team	Every weekday	The Team
Agenda	Informing the supervisors about the content of the meeting	Team member in charge of the task	24h before the meeting	Supervisors
Weekly meeting with the supervisors	Evaluating the progress of the project and having counseling on the ideias propozed	Supervisors and the Team	Every Thursday	Supervisors and the Team
Weekly team meetings	Make an analysis of the progress made and make a reassessment of the planning so far	The Team	Every week (on the most convinient day for every member)	The Team

3.8 Risk

Managing risk is a useful tool for measuring the impacts of tasks, measuring project feasibility, and generally planning more carefully. Without good risk management, there is no good way to come up with good alternatives for problems that may arise, so there is no way to control the impact that the tasks have on the project.

Good risk management requires identifying, analyzing and assessing all the possible risks.

In table 6 is presented a description of the risk, its causes and effects, control mechanisms, the response strategy and the rank.

Note:

Low = 1, Medium = 2, Strong = 3.

The Rank number comes from the multiplication of the impact and the probability.

Explanation of strategies:

Accept: Accepting the risk and do nothing.

Transfer: Transfer the risk to someone else.

Avoid: Eliminate the risk.

Mitigate: Decreasing probability or impact.

Table 6: Risk Management

Description	Cause	Effect	Trigger	Response strategy	Impact	Probability	Rank
Internal risk							
Teamwork disagreements	Misunderstanding. Problem of communication.	[Time] Efficacy of the work. Delay of work	Differences of opinions. Bad communication	[Mitigate] Try better communication practises. [Accept]	1	2	2
Team member missing	Sickness, irresponsibility, accident	[Time] Less working capacity, less diversity of opinions	Lack of commitment / sense of responsibility	[Mitigate] Encourage/Motivate team members for the project. [Mitigate] Promote organization and responsibility [Transfer] Change the responsibility of the tasks to another team member.	2	1	2
External risk							
Late delivery of materials	Suppliers didn't hold the delivery time. Transportation strike. No stock.	[Time] Impact on the time delay and the development of the product	Tracking the transportation online	[Avoid] Order components as soon as possible and verify transportation	3	2	6
Incorrect components are delivered	Suppliers behaviour, verification	[Time]/[Costs] Increase time delay in the development of the prototype, and costs.	Checking the feedback of suppliers and order acknowledgement of receipt	[Mitigate] Send back and order new components.	3	1	3
Technical risk							
Non-functional components	Bad component quality, Broken component	[Scope]/[Time]/[Costs] The product will not work. Impact on the time delay and costs	Checking the history/reliability/reviews of the suppliers	[Mitigate] Negotiate with supplier and claim the guarantee to replace the defective component. [Transfer] Have alternative suppliers.	3	2	6

Description	Cause	Effect	Trigger	Response strategy	Impact	Probability	Rank
Software not working	Bad algorithm selection. Bug. Lack of knowledge.	[Time] Programming again. Impact on the time delay	Not testing continuously the code.	[Avoid] Change programme. Testing continuously the code. Redesign code.	3	2	6
Growing process not working properly	Bad implementation of the process. Process selected not appropriated	[Time]/[Costs] Time delay (deadlines). Delay or inviabilite of prove of concept. Mushroom not eatable	Not testing process carefully. Not selecting the right process.	[Avoid] Test the process several times before implementing in the device. Change process	3	1	3
Final prototype not working	Software problems. Hardware problems, Wrong implementation	[Scope]/[Time]/[Costs] Time delay (deadlines). Final device does not work, can't be tested.	Not testing continuously the device in each stage	[Avoid] Make several tests during the development, and test each sensor and actuator separately. Buy other components, redesign the device.	3	1	3

3.6 Procurement

Managing Procurement properly can support purchasing goods and services from external suppliers in the most efficient way. Quality and costs of goods as well as costs related to postage are crucial aspects to keep in mind while developing a procurement strategy. As there is a variety of potential suppliers in the market, materials could come from any website or local shop.

For our project to be efficient and successful, we will be making use of the supplier relationship management, also known as SRM. This is a strategic and segmented approach, executed on the entire supply base, to maximize value and minimize risks. **[23]**

The SRM method contains the following five steps:

- **Step 1** – Supplier identification: The first step in the SRM method is supplier identification. The company must sort out and identify all its suppliers, to whom they paid invoices over a certain period.
- **Step 2** – Supplier segmentation: This is an important step. The long list of suppliers to whom invoices have been paid must be segmented. Segmentation helps to find those suppliers that are capable of contributing to the business strategy. Only these, limited number of suppliers are worth the time and effort to build a close relationship and partnership, with.
- **Step 3** – Relationship analysis: Mainly for the top segment of suppliers classified as interesting to build a partnership with, the company must determine the existing relationship type. This is realized by using the supplier relationship analysis tool.
- **Step 4** – Relationship management: Mainly for the top segment of suppliers the existing relationship type needs to be managed towards the ideal relationship type, which is the leverage-core relationship type.
- **Step 5** – Evaluation: On a regular basis the SRM results and lessons learned need to be documented and evaluated. This will lead to a series of recommendations towards the business like integrating the top segment suppliers for new research and development activities or proposing to restart step 2, the supplier segmentation. **[24]**

3.7 Stakeholders Management

Stakeholders are independent parties which have an interest or concern about something. In our case an interest for our project of creating a mushroom related business.

In order to manage them, we made a stakeholders management analysis through two different tools:

- A stakeholders analysis table represented in table 7
- A stakeholders analysis matrix represented in figure 7

Table 7: Stakeholders Analysis Table

N°	Who	Role	Influence	Interest
1	Team	Developers	High	High
2	Supervisors	Controllers	High	High
3	ISEP	Sponsor	High	Low
4	INESC TEC	Sponsor	High	High
5	I3S	Sponsor	Medium	Medium
6	Suppliers	Providing materials	Low	Low
7	Competitors	Competition	Low	Low
8	Consumers	Buying the product	Low	Low

Figure 7: Stakeholders Analysis Matrix



With the help of these tools, we know that we will put more effort informing our sponsors and supervisors on the evolution of the project since they are the Key Stakeholders. We will adapt our communication concerning other stakeholders depending on the evolution of the project and of their place and interest in our product.

3.8 Sprint Outcomes

In this section, we put available the sprint outcomes through the table 8, which details the tasks completed throughout the sprints and the velocity achieved. Sprints and their outputs and reviews are an essential part of the scrum project management method that we are using for this project.

Table 8: 3rd Sprint -21/03 - 27/03

PBI	Assignee	Planned Effort	Completed	Not Completed
Sprint 3 - 21/03 to 27/03				
ID009 List of Materials (what & quantity)	Julien,Erendiro	5hx2=10	X	
ID010 Improve leaflet	Julia,Alexander	1hx2=2	X	
ID011 cardboard scale model	team	2hx6=12	X	
ID012 Classes	team	25hx6=150	X	

PBI	Assignee	Planned Effort	Completed	Not Completed
Sprint 3 - 21/03 to 27/03				
ID013 Structural Drawings	Julien,Alexander	2hx2=4	X	
ID014 Dokuwiki References	team	5hx6=30	X	
ID015 System Schematics	Erendiro	3h	X	
Writing Marketing, Ethics, Sustainability chapters	team	24hx64=144		X
	Work capacity	85		
	Velocity	61		
Sprint 4 - 28/03 to 03/04				
ID016 Communication Presentation	Alexander,Eren,Julien,Maïke	4x1=4	X	
ID017 Eco efficiency chapter	Alexander,Ronald	2x4=8	X	
ID020 Pitch Presentation	Alexander	2	X	
ID024 Classes	team	22x6=132	X	
ID021 Ethics	Julien,Maïke	2x4=8	X	
ID018 Improve schematics and list of materials	Erendiro,Ronald	2x5=10		X
ID022 Marketing chapter	Julia	4		X
	Work capacity	108		
	Velocity	36		

3.9 Sprint Evaluations

Sprint retrospective is a meeting where a project team discusses what went well in a completed sprint and what could be improved. Team should also think of how to improve. Retrospective takes place after sprint review and before next sprint planning [25]. Our sprint retrospectives are shown in Table 9.

Table 9: Sprint retrospectives

Sprints	Positive	Negative	Start doing	Keep doing	Stop doing
1	Important work was done	Project planning was poor	Improve project planning	Focus on research	

Sprints	Positive	Negative	Start doing	Keep doing	Stop doing
2	Team has a better understanding of how to divide tasks and write them down in Planner, Brand logo and leaflet were created	Team was falling behind on writing wiki report	Provide teammates with an update of how task completion is going and ask for advice if needed	Writing report	
3	Wiki report was improved	Work was piling up and some tasks were moved to next sprint	Research on remaining report chapters	Writing remaining report chapters	
4	Ethics and Eco-efficiency chapters were completed in report, Team had a meeting with potential sponsors	Project Planning chapter was not done	Project Planning chapter	Refining report	

3.10 Conclusion

By properly defining project management has allowed the team to define a logical timescale for the project as well as addressing any potential risks and limits. It has determined an optimal management strategy in order to achieve all objectives. By defining sprints and through previous sprint analysis helps the team analyse their workflow and measure how well they work as a multidisciplinary team and adjust work ethics accordingly. Through risk analysis the team was able to analyse and overcome any potential setbacks. The team's success will be determined by how well they can manage their time and how well they can stick to the optimal project management strategy.

The next chapter the team will begin to develop their marketing plan and defining potential marketing strategies based on market research.

4 Marketing Plan

4.1 Introduction

Marketing is a complex process, that is why there are many definitions of it. One of the most popular was defined by Philip Kotler, who is the main authority of modern marketing. Marketing is described by him as the process by which companies create value for customers and build strong customer relationship in order to capture value from customers in return [26]. In this chapter, it would be briefly described many activities such as marketing research, product development, distribution, pricing, advertising, personal selling, and others – designed to sense, serve, and satisfy consumer needs, while meeting the team's goals.

Our product is providing a service with all the needed resources and information to grow mushrooms at home. In the offer, it is included fully colonized mycelium grow-kit, which gives the customer fresh

organic oyster mushrooms in one to two weeks with minimal effort. After the kit stops producing mushrooms, the customer can simply return it to the store and replace it with a new one. In order to give customers the choice the kits are planned to come in a range of sizes to satisfy all needs, not only a hobbyist and industrial but also an educational one.

4.2 Market Analysis

Coffee Market

According to “Statista” the coffee market worldwide is worth over 79 Billion € in 2019 and has an expected annual growth of 4.8 % (CAGR 2019-2023) [27], being the European market worth over 31 Billion € in 2019, with an expected annual growth of 3.1 % (CAGR 2019-2023) [28], and furthermore the Portuguese market is worth over 816 Million € in 2019 with an expected annual growth of 2.1 % (CAGR 2019-2023) [29].

1000 kg of fresh berry gives about 400 kg of wet waste pulp [30]. Portugal has an annual coffee consumption of about 40 tons of coffee which accounts for 16 tons of coffee waste every year [31].

Portugal is the third country that pays the most for coffee [32].

Mushroom Market

The worldwide mushroom market was evaluated in about 35 billion USD according to “FreshPlaza” in a recent study dated to 2015, between 2016 and 2021 is expected an overall growth on the market of about 9.2 % [33]. Some sources even state that the market is expected to be worth 50 billion by the end of 2019 [34].

The biggest growth is expected in the Asian countries. Mushroom consumption in China, Japan and India is quite large. Partly because of the growing focus on healthy and organic foods, demand in these countries will continue to grow. Europe is the largest market for cultivated mushrooms, accounting for more than 35 percent of the global market. Moreover, demand is on the rise in North America, and South America is also recording an explosive growth. Meanwhile, Africa and the Middle East recorded a reasonable growth [35].

The main species of mushrooms consumed in Portugal are white mushroom (*Agaricus bisporus*), brown mushroom (*agaricus subrufescens*), shiitake (*Lentinula edodes*), black mushroom from Japan (*Hypsizygus tessellatus*), and wild mushrooms [36].

The domestic market is made mostly through hypermarkets, supply markets, hotels and restaurants. According to data from the GPP (Planning, Policy and General Administration Office), about half of the production is disposed of outside the country, namely for the Spanish and French markets [37].

Through an inquiry made by [38] it was possible to conclude that one of the major obstacles in the commercialization of mushrooms is the establishment of distribution channels, followed by the difficulty of financing and thirdly the culinary culture [39].

Sustainable foods market

Growth in Healthy Eating in Europe Across all four types of wellness food, shoppers are buying more now compared to 2-3 years ago, healthy food had increased by 41 %, organic by a third (34 %) and vegetarian and free-from foods by a quarter (26 % and 24 % respectively).

What's more interesting though is that this sector still has far to go. When asked in the next six months whether they intended to spend more, just under a fifth were going to increase their spending across the four different categories [40].

Growth in Healthy Eating in Portugal As shown in a study conducted by the Center for Applied Studies of Catholic-Lisbon, School of Business & Economics in partnership with ANIPLA regarding Portuguese dietary habits 65 % of respondents prefer to consume only organic foods [41]. To further support this growth, the Portuguese Association of Distribution Companies (APED) confirms that "the category of organic products is in full development" and cites the "Target Group Index" study, published in 2018 by Marktest, according to which 47,7 % of Portuguese buy organic products [42], and this growth has been followed by a strong commitment by most of the big supermarkets in their own biological array of products, making them no longer a niche market, occupying more and more space on the shelves, and at more affordable prices. Pingo Doce, which already commercialized organic fresh products, recently launched a new brand of its own, "Go Bio", with processed products, joining Aldi, Continente, El Corte Inglés, E. Leclerc, Intermarché, Jumbo and Lidl [43].

4.3 SWOT Analysis

SWOT analysis is helpful tool for developing business strategy.

SWOT stands for:

- S- Strengths
- W- Weaknesses
- O- Opportunities
- T- Threats.

Strengths and weaknesses are internal according to the company

(factors that can be controlled and changed).

Opportunities and threats are external according to the company

(factors from the outside environment, which should be monitored but they are impossible to change)

SWOT analysis is presented in the Figure 8:

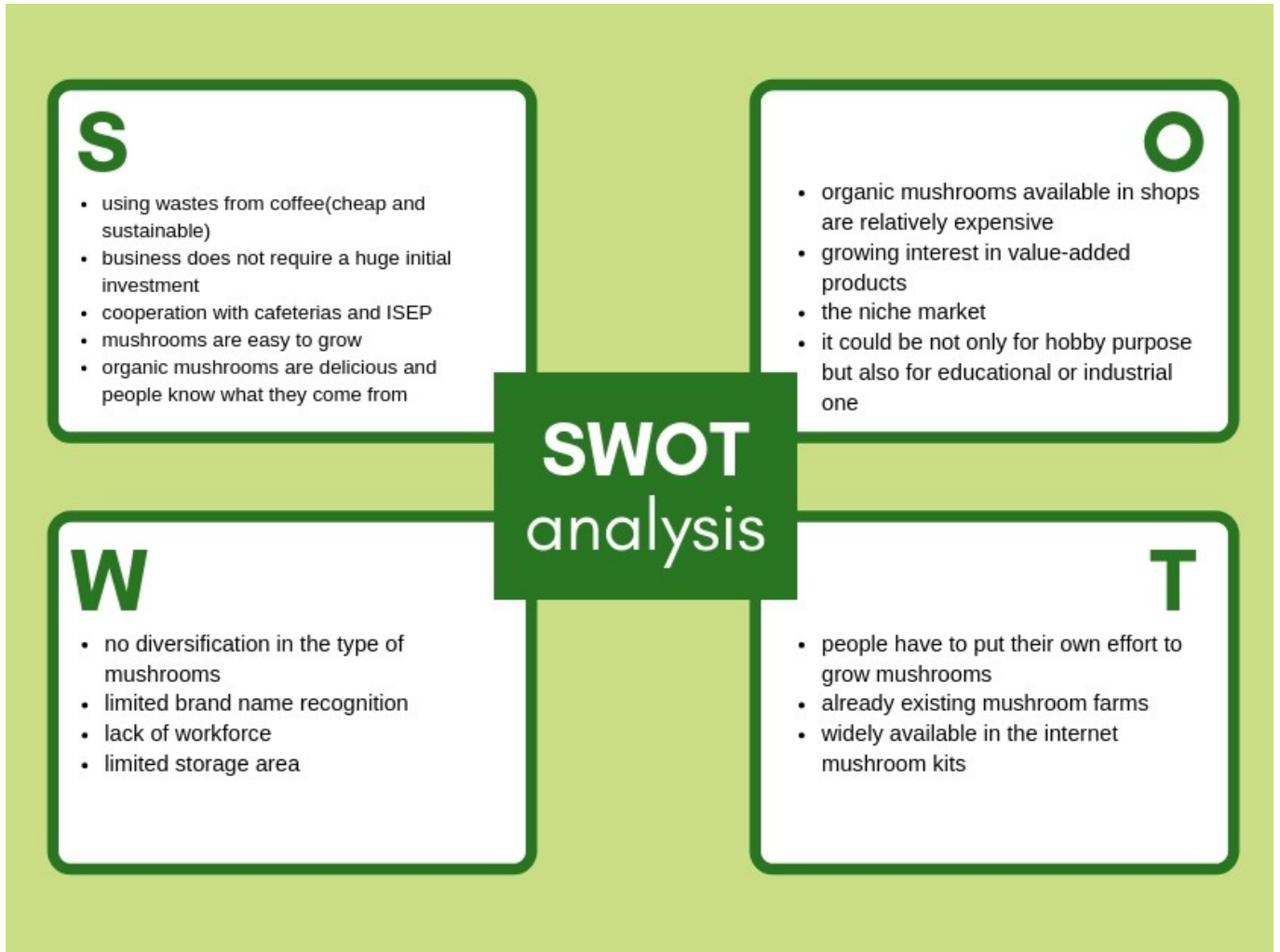


Figure 8: SWOT analysis

4.4 Strategic Objectives

Strategic objectives are one of the fundamental building blocks of developing a strategic plan. Strategic objectives are long-term and should be aligned with business mission and vision. Marketing strategies are detailed blueprints on how to achieve marketing objectives. Strategies lists all steps and specific actions needed in order to achieve objectives. Marketing objectives should be specific, measurable, achievable, realistic and time-sensitive [44]. Strategic objective can be separated into various categories including, Economical objectives, customer objectives, and Environmental objectives.

Economical strategic objectives

- Develop a Business based around mushroom cultivation which is both profitable and economically sustainable.
- Maintain growth for the first 5 years of operation.

Customer/Learning strategic objectives

- Introduce an innovative solution into an existing market.
- Build customer database by introducing a high-quality product and service.
- Provide high quality training and workshops for customers. To encourage customers to live in a more sustainable way.
- To continuously learn and adopt current best practices.

Environmental Strategic objectives

- To adopt a circular approach to waste.
- To adapt processes to be efficient as possible to reduce carbon footprint.
- To continually adopt to best environmental practices.
- To spread awareness to encourage a more environmentally friendly practices.

4.5 Segmentation

4.5.1 Demographic

Age:

Regarding age basing on the survey [\[Elisa Boin & João Nunes, 2019\]](#) as respondents were older, they were more likely to eat fresh mushrooms more often, so we want to target our product to adults (both younger (21-35) and older (35-55))

Gender:

According to a survey [\[Elisa Boin & João Nunes, 2019\]](#), women were more likely to consume fresh mushrooms with higher frequency, but there is no need to create a target group basic on gender when selling the product which is dedicated for everyone.

Income:

The initial plan is to divide the sales into three levels basing on the interest, in order to make it affordable for everyone.

Family life cycle:

The product is dedicated mainly for families and households.

4.5.2 Psychographic

Personalities:

The potential customer should be an open-minded environmentally aware person. What is more, the person has to take an interest in growing vegetable process and eating organic food.

Motive:

The motive of the consumer should be sustainable food production of healthy food at home.

Lifestyle:

The customer lifestyle should be living the life green in compliance with the earth.

4.5.3 Behaviour

Not only a one-off purchase of a mushroom farm designed to grow your own organic plant compatible with the environment is it expected but also a development of a loyalty customer relationship where waste to fungi will offer substantive support as well as lifetime analysis and technical support.

4.6 Strategy/Positioning/Brand

4.6.1 Positioning Statement

For all mushroom lovers who want a high quality fresh and locally grown product, Waste to Fungi is the sustainable oyster mushroom farm that delivers the kit which gives the possibility to grow easily ecologically from coffee wastes delicious, tasty oyster mushrooms, unlike traditional growing kits and mushroom farms, Waste to Fungi offers the product which is simple, easy to use, supports local economy and it is eco-friendly oriented by minimizing CO2 emissions caused by logistics and what is more, transforms waste into nutritious food.

4.6.2 Benefit

The concern on product benefit should be not only living life green but also nutrition and healthy aspects of eating mushrooms. Oyster Mushrooms are very healthy and nutritious. A cup of raw Oyster mushrooms provides around 28 calories and 0.35 grams of fat, 2.85 grams of protein and 2 grams of fibre. The same amount also provides 361mg of potassium, 0.095 grams of Vitamin B6 and 33ug of Folate. Oyster mushrooms are loaded with nutrients and vitamins which make them ideal for a healthy diet. They are free from fat, cholesterol, gluten, low in calories and sodium. They have high amounts of iron compared to meats.

4.6.3 Competition

4.7 Adapted Marketing-Mix

Marketing mix is a framework for the tactical management of the customer relationship, including (the 4-Ps):

- product
- price
- place

- promotion

4P model is presented in the Figure 9:



Figure 9: 4P model

4.8 Budget

4.9 Strategy Control

4.10 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

Based on this market/economic analysis, the team decided to create <specify the type of product> intended for <specify the market niche> because ... Consequently, the team decided to create a product with <specify the features>.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Provide here the summary of this chapter.

With more and more pressure on businesses to be sustainable, advances in environmental management has improved drastically over the last years however with environmental concerns becoming more and more present businesses today need to take more action and responsibility to ensure a healthy and sustainable future. Businesses usually focus their efforts in environmental control on the end of the product life cycle which actually don't produce environmental solutions, but rather prolong the problem. More environmentally conscious businesses are implementing other sustainable concepts and practices that have a more significant impact on the environment, emphasizing the principles of maximum value with minimum resources. These concepts and practices include optimising eco-efficiency, extending product responsibility and function, design for the environment, design product services and by-product synergy (one industries waste stream is another industry's primary resource). Many of these concepts are derived from a more circular economy business model. This model aims to transform traditional linear models of production where by raw materials enter and products and its waste exit the system into a more integrated (circular) industrial ecosystem. This model uses optimisation of energy and material consumption and waste minimization, where the non-valuable outputs of one process (commonly denominated 'residual waste') serve as valuable input for other processes. [47] Businesses must analyse their product life cycle and decide what areas are best suited to implement potential solutions and optimise as much as possible. Businesses need to go above and beyond environmental regulations in order to reduce the environmental impact of their product and services rather than not making it worse. Each stage in the product life cycle must share this responsibility and implement potential solutions as best as possible. In order to for these efforts to be successful, the economic and regulatory systems surrounding thee development of the business must be considered to better support potential solutions and encourage better environmental practices.

5.2 Environmental

Waste to Fungi pursues the idea of being sustainable as a business. It means adopting a more circular approach by which materials are reused that would be otherwise thrown away. Coffee leftovers are used as a substrate for mushroom to grow on. This means the service uses by-product synergy as one industry's waste is used as another primary resource. Grow kits will use plastic buckets from various food industries, thereby extending the life cycle of the buckets. Growing process will be carried out in the same containers. Waste resource collection and product distribution will all be conducted locally to minimize the negative impacts. It means less pollution created by transportation. Electrical components and mushroom spawn may have to be sourced externally, however efforts will be made to source as local as possible. This not only reduces emissions but also supports a more local economy. Process of mixing substrate with mycelium does not require energy as it can be done by the human hand. Oyster mushrooms are going to be grown domestically, which means we shorten the gap between the consumer's plate and production point, thereby reducing the food's carbon footprint. After the growing process has been completed, buckets are returned to our company for a new cycle promoting a more circular economy. Buckets have a monitoring system (as an option) which allows the consumer to maximize outputs without increasing inputs. The system is modular which allows defective components to be easily replaced, rather than replacing the entire system. A full life cycle assessment could be conducted in order to point out areas of weakness in the business that can be optimized to make it as sustainable as possible. This will be done further into the chapter.

5.3 Economical

Economic sustainability are strategies for making the most out of available resources, to their best advantage. The idea is to promote the use of these resources in a way that is both efficient, responsible and likely to provide long-term environment and economic benefits, while returning profit. The concept uses coffee waste and plastic buckets from another industry providing a suitable substrate and growing container for no cost. Deposit system is implemented into the business which uses concepts of circular economy to not only produce less waste but to also reduce costs. It maximizes reuse of materials, but may reduce profits but also reduces waste. The company adopts the a return policy to be as sustainable as possible but must make sure it generates enough profit to maintain the business.

5.4 Social

With the concept of sustainability, people mostly think of the environmental and economic side of it. But more attention is now being put on the idea of social sustainability, where by before was neglected. Social sustainability refers to the well being of all. By definition, it is the ability of a community to develop processes and structures which not only meet the needs of the its current members but also support the ability of future generations to maintain a healthy community. [48] Industries are recognising that social justice and social rights are integral part of sustainability. It is truly an international effort, as the groups creating the international set of social standards for all members are called the Fair Trade Labeling Organization International. They are researching aspects of labour welfare and rights, making recommendations, and hoping soon to implement new standards through developing guiding documents. [49] The goal as a company is to provide people with the access to fresh, healthy and organic food which in terms adds to their quality of life. Surrounding the business there is an educational aspect by which the service hopes to provide information and courses that teach people and families about the process and benefits of growing mushrooms at

home. This is not only an enriching and rewarding process but expands people awareness and knowledge in sustainable food systems as well as providing food security. The company will also encourage the fair trade of local resources to stimulate the development of sustainable communities.

5.5 Life Cycle Analysis

Life cycle assessment:

The life cycle assessment of a product (LCA) is a great tool to calculate the environmental emissions at each point during the life cycle of the specific product or industry, starting from extraction, manufacturing, use and distribution all the way to disposal. [50] It looks at a product from cradle to grave. As people demand more sustainable foods this tool becomes more necessary to consumers as this information can effect their purchasing decisions. The objective in this section is to analyse the environmental impacts of waste coffee grounds coffee production and see if there are any weak areas within the cultivation process which can be optimised to be made more environmentally friendly.

Raw material extraction

In order to cultivate the mushrooms, you need a substrate for the mycelium to colonise on. In this case waste coffee ground is being used. By using another industries waste as one of the main resources in the production of the mushrooms is a big sustainable advantage as it not only gives value to waste which would otherwise be thrown away but also uses more of the coffee grounds potential by using the remaining 99% of the nutrients still in the coffee grounds after extraction to grow mushrooms. Another big advantage is that by providing a service of waste management for the waste coffee ground makes the resource free making it more economically sustainable. Other resources such as plastic using in the production process need to be taken into account too however if the business is able to repurpose even recycle buckets as grow containers instead of using single use grow bags then again, the business is adding value to recycled material and extending the life of the buckets too. Production process/Use of Product. The actual production of the mushrooms has almost no negative effect on the environment. Despite the small control unit for the grow chamber which requires small amounts power to use, the process requires very little resources. Small amounts of light and water to optimise the conditions of the grow chamber but this is all.

Post Harvest

Once the mushrooms have been harvested the waste coffee ground will no longer have any nutrients left in it. This can now be used into compost and other growing mediums for plants. The grow buckets can be reused over and over to a certain point therefore extending the life cycle of it. Sterilization of the bucket is require but can be done with rubbing alcohol which does not require high amounts of energy nor does it have any negative effects on the environment if used appropriately. By introducing a deposit system for the buckets and the growing chamber it encourages as much reuse as possible.

The whole cultivation process all the way from resource extraction to post harvest tries to adopt a more circular approach by which resources are fed back into the process to maximize their use and extend the life as much as possible and by not using any single use plastics. Because production is done at home is also heavily reduces the foods carbon footprint as it does not have to travel to reach your plate.

5.6 Conclusion

As people become more aware of sustainability practices, businesses will try to adopt a more circular economy approach. Where by waste is filtered back into production therefore less extracted resource are used in a production process. Products are made of reused materials. When a lifetime of a product is exceeded, materials and parts are recycled. Waste to Fungi aims to be sustainable through reusing coffee waste and plastic buckets, this adds value to another industries waste and so they life is extended. There is the added benefit that these materials are free and will not generate much costs for the business. Furthermore, energy consumption is minimized by avoiding sterilization process as coffee is already sterilized through the brewing process. In addition to that, process of mixing substrate and mushroom spawn can be done by human hand, again saving energy. Circular economy concept will be achieved through establishing a cycle for our product. Once customer has harvested mushrooms from the grow kit, it is returned, cleaned and reused as a growing container. A small low-power monitoring system is added to the grow kit making it easier for the customer to track the humidity and temperature levels to maximize yields and efficiency of the kits. Process of growing mushrooms at home is educational as well as rewarding, providing fresh, healthy and tasty food. This not only promotes a healthy diet but also promotes good environmental practices. The business aims to be sustainable not only through its practices and techniques but by spreading awareness and promoting sustainability by connecting people back to healthy, organic and low carbon food.

6 Ethical and Deontological Concerns

6.1 Introduction

Ethics regarding business is not simply about regulatory compliance and legal protection. When talking about ethics, it includes a commitment to quality products, attentive customer service, and taking care of employees and local community. As a company, it is very important to take care of ethical concerns as it shapes its image and market position as well as it contributes to its trustworthiness. It ensures stable development and should, therefore, be the basis for the functioning.

As ethical behavior is of utmost importance while designing a new product, this chapter will cover all different aspects such as Engineering, Environmental and Sales and Marketing Ethics. In figure 10 the most important ethical values are represented.



Figure 10: Ethical Values

6.2 Engineering Ethics

Engineers through their position in the industry, and the creation and development of new products have a really important role, it is therefore really important for those professionals to behave in a good ethical and moral way.

Indeed, engineers play a major role in today's society, through three main different ways:

Human: Engineers should be developing and creating products in accordance with safety, health and welfare of the public.

Environment: Engineers should be developing and creating products that are not, or as less harmful

as possible to the environment. By studying the life cycle of the product, in order to achieve it. This is one of this century biggest challenging as we have to face climate change.

Society: Engineers should be developing and creating products for the benefits of whole and contributing for a better society, by creating solutions to connect, or help people in a more general way.

Code of ethics were discussed in many engineering societies, the one that we thought was the more up to date is the Code of Ethics brought by the National Society of Professional Engineers [51].

Their Code of Ethics is composed of three main things:
Fundamental canons, rules of practice, and professional obligations.

The fundamental canons being the following:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

6.3 Sales and Marketing Ethics

When thinking about advertising a product, doing it ethically is less of a marketing strategy and more of a philosophy which should seek to promote fairness, honesty, and responsibility. Ethics is always a difficult subject because everyone has slightly different ideas about what is right and what is wrong. Therefore, ethical marketing is not a strict list of rules to follow, but a general set of principles which should support companies as they decide on their marketing strategies. In fact, there are 8 different principles to be aware of:

1. The common standard of truth will be observed in all forms of marketing communication.
2. Personal ethics will guide the actions of marketing professionals.
3. Advertising is set apart from entertainment and news and the line is clear.
4. Marketers will be transparent about who is paid to endorse their products.
5. Consumers will be treated fairly, depending on who the consumer is and what the product is.
6. Consumer privacy will be respected and upheld at all times.
7. Marketers will comply with standards and regulations set by professional organizations and the government
8. Ethics should be discussed in all marketing decisions in an open and honest way. [52]

Also, since unethical advertising is not necessarily against the law and is just as effective as ethical marketing, many companies use it for their advantage. But for our company to have a reliable and trustworthy reputation, we want to treat our customers fair and advertise our service and product in the most transparent and honest way possible.

6.4 Environmental Ethics

As the world population increased sevenfold from 1 billion up to over 7 billion inhabitants [53] during

the past two centuries, so did the consumption of our planets natural resources. This behavior gave increasingly grave stress on the life-supporting capacities of our planet. As a result, humans became responsible for several environmental issues such as global warming and climate change as they forget about the value and the moral status of the environment and started to exploit the planet and non-human creatures for their own advantage and comfort. The main core of environmental ethics is finding the balance between social, economic and environmental aspects and try to be more sustainable in all actions. [\[54\]](#)

When designing our Mushroom Grow-Kit, we are conscious about our impact on the environment - and we want to keep it as low as possible. As our service strives to be a completely circular one, taking back Grow-Kits which do not grow mushrooms anymore and reusing the chamber as well as using coffee grounds as the main component of our product which would otherwise be thrown away, we are making an effort on being as sustainable as we can be. We do not want to contribute to the pollution of the planet and produce more waste. Also, because people will be able to grow their mushrooms at home we decrease CO₂-emissions to a minimum as mushrooms won't need to travel long to finally arrive at the end-consumer. This way we are doing our best to act as environmental ethically as possible.

6.5 Liability

Companies willing to create and sale a product will have to confront to the liability of their product at a certain point.

Liability being the legal aspect of the product, preventing the company to be sued for damages or incidents created by their product or its use.

In order to avoid any issues concerning liability with our product, we decided to comply with the following EU directives:

- Unordered List ItemMachine Directive (2006/42/CE 2006-05-17)
- Unordered List ItemElectromagnetic Compatibility Directive (2004/108/EC 2004 12 15)
- Low Voltage Directive (2014/35/EU 2016-04-20)
- Radio Equipment Directive (2014/53/EU 2014-04-16)
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27)

Since we deliver a service allowing to grow food, that would be eaten after growth. We will make sure to comply with existing food directives in Portugal in order to avoid any case of food poisoning.

We decided to create a manual explaining how to properly use the product, protecting us from incidents caused by a wrongful use of the product. We also decided to choose trustful suppliers in order to minimize the risks of failures and potential liability issues.

6.6 Conclusion

After precisely dealing with the ethical challenges, we are even more determined to respect all the aspects mentioned regarding ethical behavior. While further developing our product we will be conscious about treating our employees and customers as well as our environment as ethical as possible. Our main concern is the environmental ethics as we strive to provide a completely circular service in which no waste will be produced and the local economy will be supported. We will even go

further and use "waste" as the main component of our product. This way we won't only be avoiding to produce any waste but also contribute to make a new purpose out of someone else's.

In the following chapter, the Project Development is represented.

7 Project Development

7.1 Introduction

With a better understanding of the available solutions to the problem and the scientific field in which the organization is inserted (State of Art), the Market Analysis as well as all ethical and sustainability considerations, it is necessary to develop a functional prototype as proof of the concept. This chapter aims to provide a better understanding of the entire development process of this prototype, going from an overview of the structure of the system to the closest of the final product as possible.

7.2 Drafts and Initial Sketches

The design proposed in this chapter is a result of an analyse of different approaches to better solve the problem in question, starting with a "map of concept" (Figure 11) relating all relevant ideas, in that way facilitating the understanding of which solutions are the most efficient and effective.



Figure 11: Map of concepts

After breaking the cultivation process into stages, the team looked for areas within the process that could be optimized to be made either more efficient or more environmentally friendly by reducing waste. Another area that was looked into was if the process could be simplified for growers at home. Despite a mushroom farm being quite sustainable as it is, there were key areas that let the process down. There seemed to be quite a lot of single use plastics being used which could easily be substituted for more durable solutions. A conclusion was made that a low cost and simple solution was missing for users who wanted to grow home on an adjustable scale which was not too cost and labor intensive.

BUCKET GROW!

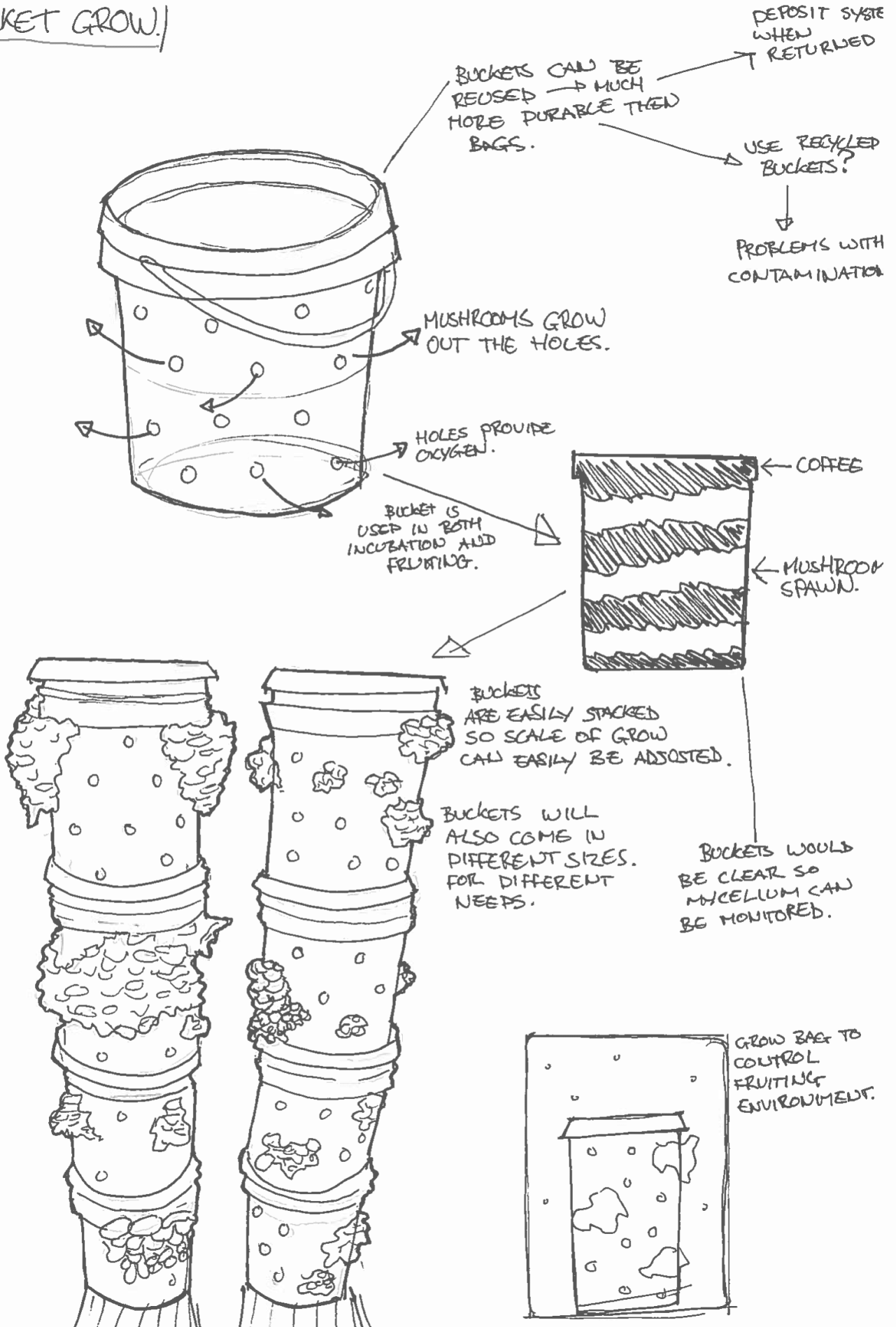


Figure 12: Bucket concept

A potential solution was defined on this section. Instead of using grow bags which would only be used once, why not use buckets to grow mushrooms. Buckets are much more durable and can easily be reused. Buckets come in a range of sizes and can easily be stacked for a modular cultivation process. Recycled buckets could be used and reused to adopt a more circular approach instead of a more traditional linear process by which the grow bags are used and then disposed of. The grow buckets can be accompanied with a modular fruiting chamber that not only allows the grow scale to be modular but allows growing conditions to be optimized and controlled to maximize harvest yields.

GROW BAG.

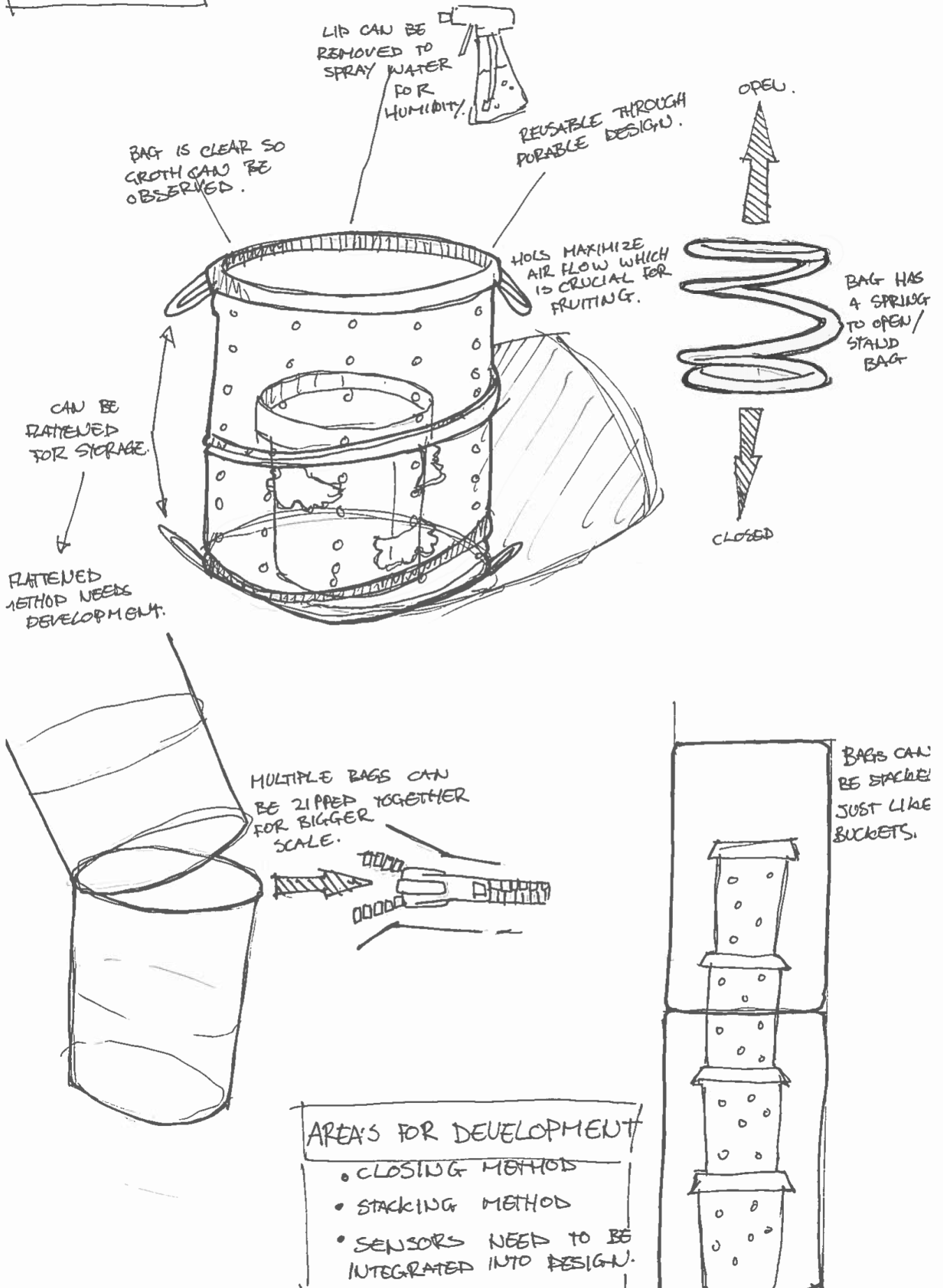


Figure 13: Chamber concept

The chamber can automate the conditioning of the buckets by means of sensors and actuators thus making the entire growing process much easier for the consumer. The design also uses a spring to mount the grow bag. This makes it very easy to fold away for storage or transportation.

7.3 Chamber Blackbox Diagram

For the chamber is idealized a system that can accurately read the temperature and humidity, and through those values, present relevant information to help the user maintaining the ideal conditions for the mushroom cultivation, or automatically control the condition in order to keep the system always in the right conditions. The described system can be represented in terms of its inputs and outputs (Black Box Diagram), as shown in Figure 14.



Figure 14: Blackbox diagram

Power supply: A power supply is a device that supplies electric power to an electrical load.

Sensors: A sensor is a device that can convert a specific physical/chemical stimulus in to another physical quantity (for example: an electrical stimulus (voltage, current, resistance, etc)) usually for measurement and / or monitoring purposes.

Actuators: An actuator is a component responsible for controlling a mechanism or system.

Micro-Controller: The micro-controller is the “brain” of the system responsible for processing the signals received by the sensors and activating the actuators.

7.4 Architecture

[INTRODUCTION]

7.4.1 Schematic

The schematics is represented in figure 15 and 16.



Figure 15: Schematic



Figure 16: Schematic real life visualisation

7.4.2 Cardboard model

The cardboard model is shown in Figure 17.



Figure 17: Cardboard model

7.4.3 Solid Works model

The solid works model is shown in Figure 18.



Figure 18: Solid Works model

7.5 Components

7.5.1 Comparing micro-controllers

In figure 10 the micro-controllers are being compared

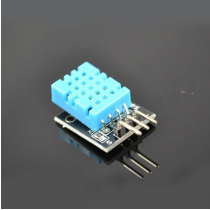
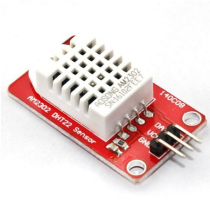

Table 10: Comparing prototyping boards

Microcontroller	Price (€)	Input Voltage (V)	Clock Speed (MHz)	Analog In/Out	Digital In/Out	SRAM (kB)	Flash (kB)	USB	Wi-Fi	Bluetooth	Source
 Espressif ESP32 DevKitC [55]	8.73	3.3 to 5	160	/	10	520	16 Mbit	Micro	Yes	Yes	Botnroll
 Node MCU ESP8266 [56]	9.90	3.3 to 5	80	/	17	/	/	Micro	Yes	No	BotnRoll
 Arduino Nano V3.0 [57]	12.90	7 to 12	16	8	14	2	32	Mini	No	No	Eletrofun
 Arduino Uno R3 [58]	18.70	7 to 12	16	6	14	2	32	USB Cable A to B	No	No	Eletrofun
 Wemos D1 R2 ESP8266 [59]	18,70	9 to 24	80/160	1	11	36	4000	Micro UBS cable needed	Yes	No	Eletrofun
 LoRa SX1278 display OLED 0.96 ESP32 [60]	24.90	7 to 12	240	18	28	/	6400	Micro	Yes	Yes	Eletrofun

7.5.2 Comparing Temperature and humidity sensors

Temperature and humidity sensor comparison in Table 11.


Table 11: Temperature and Humidity Sensors options


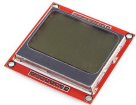
Model	Price (€)	Input Voltage (V)	Current (mA)	Temperature Range (°C)	Temperature Accuracy (°C)	Humidity (%)	Humidity Accuracy (%)	Source
DHT11 [61] 	4,15	3.3-5	3-4	0-50	+2.0	20 - 90	+4	Eletrofun
DHT22 AM2302 [62] 	12,30	3.3-5	2.5	-40 - +80	+0.5	0 - 100	+3	Eletrofun
HTU21D-F [63] 	13,93	3.3-5	3-4	-30 - +90	+1	5 - 95	+2	Mouser

7.5.3 Comparing LCD screens

LCD comparison in Table 12.



Table 12: LCD screens options

Model	Price (€)	Input Voltage (V)	Current (mA)	Display size	Background color	Characters color	Source	Note
Display LCD 16x2 1602 I2C IIC [64] 	7,20	4.5 - 5.5	0.35 - 0.6	16x2	Blue	white	Eletrofun	Integrates an I2C module facilitating the connection between the lcd and the microcontroller.

Model	Price (€)	Input Voltage (V)	Current (mA)	Display size	Background color	Characters color	Source	Note
Display LCD 16x2 1602 I2C IIC [65] 	7,20	4.5 - 5.5	0.35 - 0.6	16x2	Green	white	Eletrofun	Integrates an I2C module facilitating the connection between the lcd and the microcontroller.
Display LCD Nokia 5110 [66] 	8,30	4.5 - 5.5	0.35 - 0.6	84x48 Pixels	Green	Black	Eletrofun	Monochrome graphic display. Allows drawing of graphics and text simultaneously. Requires external circuit before connecting with micro-controller.

In case of using a micro-controller without a wifi/bluetooth connection integrated, a external wifi/bluetooth module is necessary. In table 13 some options for those modules are presented.

Table 13: Bluetooth and Wifi modules

Module	Price [€]	Input Voltage [V]	Current [mA]	Source
Wifi ESP8266 	4.25	3.3 to 3.6	40	BotnRoll
HC-06 Bluetooth module 	6.90	3.6 to 6	170	BotnRoll

7.5.4 Power supply calculation

In [Table 14](#) the power calculations are being shown.

Table 14: Power calculations

Component	Quantity	Voltage [V]	Current [mA]	Power [mW]
Dht22	1	5	4	2.5
L298D	1	12	/	/
Fans	2	12	/	/

Component	Quantity	Voltage [V]	Current [mA]	Power [mW]
Total				/

7.5.5 Full Components list

In table 15 the full component list is shown.

Table 15: Full components list

Component	Quantity
Dht22	1
L298D	1
wires	Still to be defined
LED	Still to be defined
Breadboard	1
Espressif ESP32 DevKitC	1
Fans	2
10k Ω Resistor	1
220 Ω Resistor	1
12V battery	1
Adapter/Charger 12V	1

7.6 Functionalities

7.7 Tests and Results

7.8 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

8 Conclusions

8.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

8.2 Future Development

Provide here your recommendations for future work.

Bibliography

[1] Name, Title, Year. Available at URL [Accessed in February 2015].

Appendices

- [1], [2] Growcycle. [How to grow Oyster Mushrooms](#). [Accessed in April, 2019].
- [3] European Commission. [Machine Directive \(2006/42/CE 2006-05-17\)](#). [Accessed in April, 2019].
- [4] European Commission. [Electromagnetic Compatibility Directive \(2004/108/EC 2004 12 15\)](#).. [Accessed in April, 2019].
- [5] European Commission. [Low Voltage Directive \(2014/35/EU 2016-04-20\)](#).. [Accessed in April, 2019].
- [6] European Commission. [Radio Equipment Directive \(2014/53/EU 2014-04-16\)](#).. [Accessed in April, 2019].
- [7] European Commission. [Restriction of Hazardous Substances \(ROHS\) in Electrical and Electronic Equipment Directive \(2002/95/EC 2003-01-27\)](#).. [Accessed in April, 2019].
- [Collabnet Versionone, 2019] Collabnet Versionone, 2019. [What Is Scrum Methodology?](#).
- [Resetea, 2019] Resetea, 2019. [OYSTER MUSHROOM SELF-CULTIVATION KIT](#).
- [Cogusbox, 2019] Cogusbox, 2019. [CogusBox](#).
- [Reforma Agraria, 2019] Reforma Agraria, 2019. [Kit Zás - Mushrooms Oyster](#).
- [Siro, 2019] Siro, 2019. [PLEUROTUS 3L MUSHROOM KIT](#).
- [21] toolshero. [Responsibility Assignment Matrix \(RAM\)](#). [Accessed in April, 2019].
- [22] Wikipedia. [Responsibility assignment matrix](#). [Accessed in April, 2019].
- [25] Scrum.org. [What is a Sprint Retrospective?](#). [Accessed in April, 2019].
- [26] Marketing definition
- [27] Statista. [Worldwide | Statista Market Forecast](#). [Accessed in March, 2019].
- [28] Statista. [Europe | Statista Market Forecast](#). [Accessed in March, 2019].
- [29], [31] Statista. [Portugal | Statista Market Forecast](#). XXXX 20XX. [Accessed in March, 2019].
- [30] Jenny Anne Tharianand Thirunalasundari T Padmapriya R. [Coffee waste management-An overview](#). XXXX 20XX. [Accessed in March, 2019].
- [32] Kelli Simpson. [The Countries That Drink The Most Coffee And Pay The Highest Prices For It](#). March 28th, 2014. [Accessed in March, 2019].
- [33], [35] Rudolf Mulderij. [OVERVIEW GLOBAL MARKET MUSHROOMS](#). October 28th, 2016. [Accessed in March, 2019].
- [34] Markets, Markets. [Mushroom Market by Type \(Button, Shiitake, and Oyster\), by Application \(Fresh Mushrooms and Processed Mushrooms \(Dried, Frozen, and Canned\)\), & by Region - Global Trends & Forecast to 2019](#). XXXX 20XX. [Accessed in March, 2019].
- [36], [39] Marketing Agricola. [Produção e Comercialização de Cogumelos](#). XXXX 20XX. [Accessed in March, 2019].
- [37], [38] António José Moreira Araújo. [PROMOÇÃO DO EMPREENDEDORISMO LOCAL – PROJETO PARA A CRIAÇÃO DA EMPRESA](#). Novembro, 2014. [Accessed in Febraury, 2019].
- [40] International Nut&Dried Fruit. [Healthy Eating Trends in Europe](#). July 20th, 2018. [Accessed in March, 2019].
- [41] Agroportal. [Estudo da CATÓLICA – LISBON em parceria com a ANIPLA determina que a população portuguesa desconhece realidade agrícola](#). Abril 27th, 2018 . [Accessed in March, 2019].
- [42], [43] Expresso. [Portugueses cada vez mais ‘bio’](#). XXXX 20XX. [Accessed in March, 2019].
- [44] Strategic Objectives
- [Elisa Boin & João Nunes, 2019], [Elisa Boin & João Nunes, 2019] Elisa Boin & João Nunes,

2019. *Mushroom Consumption Behavior and Influencing Factors in a Sample of the Portuguese Population*.

[47] Eco Efficiency analysis

[48] =Michael S.. *What is social Sustainability*. XXXX 20XX. [Accessed in March, 2019].

[49] Eco Efficiency analysis

[50] P. - USUBHARATANA. *LIFE CYCLE ASSESSMENT OF THE STRAW MUSHROOM PRODUCTION*. XXXX 20XX. [Accessed in March, 2019].

[51] National Society of Professional Engineers. *NSPE Code of Ethics for Engineers*. [Accessed in April, 2019].

[52] Olivia Durden. *Ethical Practices in Sales & Marketing*. [Accessed in April, 2019].

[53] UNFPA. *World population trends*. [Accessed in April, 2019].

[54] Andrew Light & Alan Holland John O'Neill. *Environmental Ethics*. [Accessed in April, 2019].

[55] BotnRoll. *Placa de desenvolvimento ESP32 - ESPRESSIF*. [Accessed in April, 2019].

[56] BotnRoll. *NodeMcu Lua - Placa de Desenvolvimento com WiFi para IoT*. [Accessed in April, 2019].

[57] Procurement Academy. *Procurement Strategy Development*. [Accessed in April, 2019].

[58] Eletrofun. *Procurement Strategy Development*. [Accessed in April, 2019].

[59] Eletrofun. *Wemos D1 R2 Placa Wi-Fi ESP8266*. [Accessed in April, 2019].

[60] BotnRoll. *ESP32 WiFi Bluetooth LoRa SX1278 433MHz com display OLED 0.96"*. [Accessed in April, 2019].

[61] eletrofun.pt. *Módulo Sensor de Humidade e Temperatura DHT11*. [Accessed in March, 2019].

[62], [63] eletrofun.pt. *Módulo Sensor de Humidade e Temperatura DHT22 AM2302*. [Accessed in March, 2019].

[64] eletrofun.pt. *Display LCD 16x2 1602 I2C IIC com fundo azul*. [Accessed in March, 2019].

[65] eletrofun.pt. *Display LCD 16x2 1602 I2C IIC com fundo verde*. [Accessed in March, 2019].

[66] eletrofun.pt. *Ecrã Display LCD Nokia 5110 para Arduino*. [Accessed in March, 2019].

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