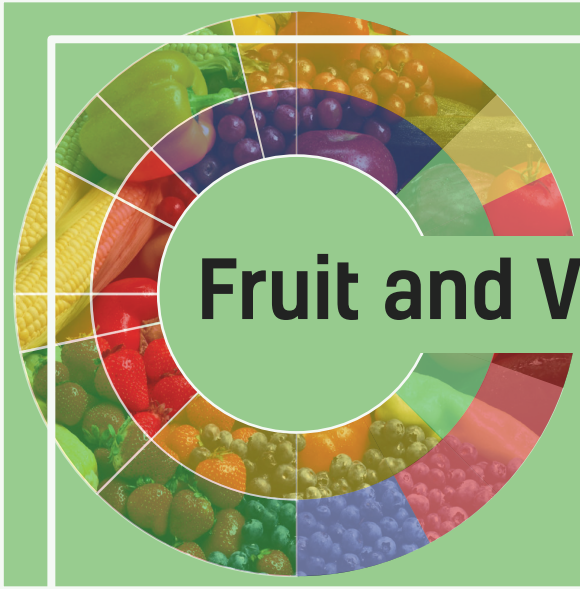


Fruit and Vegetables Packaging Solution

Nathan Blaak

Graduation project

2018 - 2019

Fruit and vegetables packaging solution

Master thesis

Nathan Blaak

19 August 2019

Author
N.C.P. Blaak (Nathan)

Graduation Thesis
Packaging solution, for fresh fruits and vegetables

University
Faculty of Industrial Design Engineering,
Delft University of Technology

Master
Integrated Product Design

Student number
4204190

Date of publication
August 19, 2019

Supervisory team
Prof. dr. A.R. Balkenende (Ruud), chair
Delft University of Technology
Professor of Circular Product Design
Design Engineering

M. Sypesteyn (Sijia) M.Sc, mentor
Delft University of Technology
Design drawing

Preface

Personal belief for this project

The graduation project is the final chapter of my education period at the Technical University in Delft. The subject of my graduation project was thought of through an inconvenience, which was translated into a question, "What is the necessity of all packaging in food products?". I want to design something that creates less waste to save the planet for future generations. The focus of the project became packaging within the area of fresh produce specifically fruit and vegetables.

Packaging in most cases subordinate the product they encase and often have a one-way ticket to the bin after being used once (Haffmans, Gelder, Hinte & Zijlstra, 2018). In 2019 we are able to produce packaging in all sizes and shapes, while not having managed to dispose of all packaging in a way that the environment is not burdened with. Evidence of the impact of packaging waste on the environment is the "plastic soup" (the plastic waste in the oceans). The organization Ocean Clean Up is founded by a student from the Technical University in Delft, who is cleaning the oceans from plastic waste. According to the Ocean Cleanup (2019), ''over 5 trillion pieces of plastic currently litter the ocean". This project inspired a contribution to saving the planet and encourage a more ecological behavior within users, by taking on a such project.
I am convinced that to make a contribution to saving the planet circular thinking is the way to go. Translate this to packaging, single-use packaging could be a thing of the past.

"Designs are not from this era if they do not take the environment into consideration"

Acknowledgement

During this project, I have received much support from friends, family, teachers and people from the contacted companies. I want to thank everyone who has supported me throughout the project.

I want to thank my family and friends who motivated me to continue working during good an bad times of this project.

I want to thank my fellow students who helped me figure out the structure of the project and helped in the ideation phases to come up with creative ideas. I appreciate the time you all took to support me.

Employees of Kordaat Product Design, although we have not been able to work together till the end of the project, I still want to thank you for giving me the opportunity to work with your company and giving me a place to work for ten weeks. I have enjoyed working and discussing ideas together.

Last but not least, my chair Ruud Balkenende and my mentor Mark Sypesteyn. You helped me to retrieve quality in my work. Although, this project took some more time, you both remained patient and helped me to receive the green light. Thank you both for your support.

Executive Summary

This thesis started with the question of "What is the necessity of all packaging in food products?". The problem of packaging waste is undeniable, an example of the cause of packing to the environment is the ''plastic soup". Plastic packaging degrades over time, which produces microplastics. Microplastics accumulate in the environment and nowadays traces of it can be found everywhere. To counter the accumulation of microplastics, less leakage of plastic waste should be achieved. This could be done by selling less single-use packaging and sorting waste better. A contribution to a solution for the packaging waste problem is performed in this project, by making a reusable packaging solution for the fresh fruits and vegetable sector. The designed packaging should be convenient for the consumer, which is why was set that the packaging solution should maintain or improve the consumer packaging experiences with reusable packaging.

The current fruit and vegetable packaging were benchmarked on functions and features, but analyzing all fruits and vegetables and their packaging was too big of scope for this project. This is why a decision process was performed on the shelf life of fruits and vegetables. The mushroom had the shortest shelf life and was therefore analysed. The mushroom is a vulnerable vegetable and is sensitive to humidity levels, pressures and carbon dioxide levels. The found mushroom packaging had features like strengthening structures for the protection of the mushrooms, and airholes for humidity levels and carbon dioxide concentrations. In interviews about the conventional blue mushroom packaging, it was discovered that consumers have a preference for transparent packaging. Also, it was discovered that with reusable packaging information that is normally printed or stuck on the packaging needs to be communicated in another way. From consumer research was retrieved that consumers lack knowledge about packaging features and production processes of fruits and vegetables. Also, consumers find the opening, closing and resealing of packaging the most important conveniences. The thresholds values of the consumer with using reusable packaging, retrieved from consumer research were the skill in filling of the packaging and no room for storage of reusable packaging.

To support the consumer in reusable fresh fruit and vegetable grocery shopping, ''the grocery tree" was designed. The grocery tree is a combined grocery bag and packaging that can hold eight packaging, which can differ in size and can be taken from the grocery tree at every time. The packaging is designed to support the consumer in the filling process of fruits and vegetables, by making packaging with instructions in the shape of use-cues and two predesigned ways of holding it. The consumer is supported in the supermarket with an app on the smartphone, which is interactive with the designed scales at the supermarkets. At home, the packaging can be used to store the fruits and vegetables, and the remaining of the grocery tree can easily be disassembled for convenience in storing.

The grocery tree is designed to eliminate single-use fruit and vegetable packaging. The grocery tree is reusable but needs the dedication of the consumer to use the product. The grocery tree has gone through optimization steps, but can be further optimized in shape, convenience and amount of material. This to save cost and to support the consumer more in fruit and vegetable shopping with a reusable packaging solution.

Table of contents

I. Introduction

Project introduction

Packaging have caused problems in the world over time, for example, the "plastic soup". The project started in cooperation with a design agency called Kordaat Product Design, who plays part in connecting the Westland companies with the city and consumers. The knowledge and connections from the design agency are used throughout the project. In combination with knowledge from multiple journals and other food packaging projects, a new vision to package fruit and/ or vegetables is designed.

This project focusses on the selling of fruits and vegetables at the supermarket. The fruits and vegetables in the supermarket are either unpacked, pre- packaged, or are packaged and weight by the consumer in the supermarket. It can be argued what the most convenient consumer experience is, either pre-packaged or packaged by the consumer. In the Netherlands, packaging free supermarkets have existed, an example is bag & buy. This grocery store had to close because of low turnovers, but it shows the willingness of entrepreneurs to create a different consumer shopping experience.

Lowering the impact can be done in multiple ways. An option could be using a biodegradable material, for example, PLA was found to be more sufficient than PP (Bohlmann, 2004). Another option could be collecting all waste by the supermarket, which is already done by collecting PET bottles.
Another option is reusing of the packaging by the consumer. When packaging is reused, the lifetime of the packaging extends to multiple life cycles. Two examples of reuse of packaging are; chocolate spread jars used as drinking glasses, and Jelly jars reused to store homemade jelly. These are two examples of reuse, one for the same purpose and one with another purpose.

To make fruit and vegetable packaging more sustainable and to maintain or improve the consumer experience the following assignment is formulated:

Design a packaging solution for the fresh fruit and vegetable sector that creates a lower environmental impact over its lifetime than the current packaging situation, in which packaging is only used once as a food packaging and then disposed of. The packaging solution should maintain or improve the consumer experience while being reusable by the consumer, at least once.

During this project, multiple stakeholders are addressed, but the project is not carried out for a specific company. When an assumption, implementation, or recommendation is done, it will be done to the stakeholder in general. During the project, a focus on a specific fruit or vegetable is made for more elaborated research into specific packaging. Also, to use as carrier for the embodiment of the packaging solution. At the end of this project, a concept of the packaging solution is made and evaluated.

To find solutions for the assignment two research questions were created, into which research is performed. The research questions are:

RQ1: How to lower the environmental impact of a fruit or vegetable with or without packaging considering every stakeholder from the grower to end-of-life?

RQ2: How to maintain or improve the consumer experience with a multiple-use packaging solution? (Compared to the current situation of one-time usage)

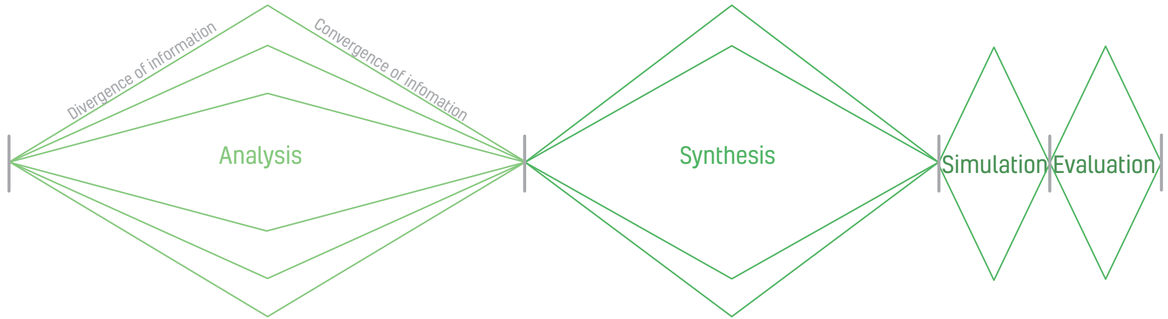


Figure 1: Approach step 1, design phases with lines illustrating the divergence and convergence of information.

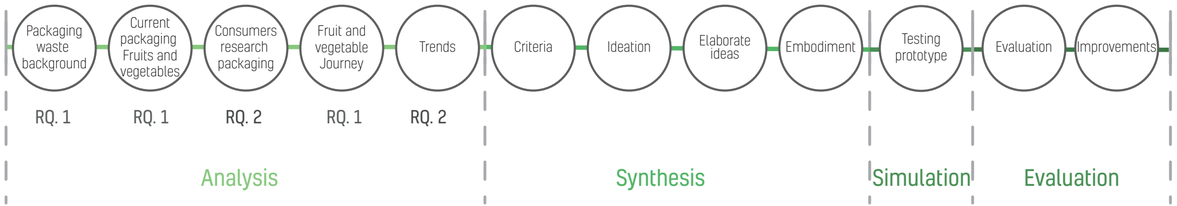


Figure 2: Approach step 2, design phases with the main subjects. The research question that is answered with the main subject is presented under the line.

2. Approach

In order to get a creative solution for the main assignment a project specific approach is created. The approach is set up in three stages, from an abstract level (figure 1) to a more detailed layout (figure 3). The detailed approach gives insight into every stage of the project. This chapter gives insight into the phases that lead to the packaging solution

In figure 1, the used four phases of a basic design cycle are illustrated, from which in this project the first two stages are longer and more time-consuming. In figure 2, the main subjects per phase are added.

To create a more detailed approach sub-questions were created from the research questions.
Sub-questions:

- What are the consumers current fruit and vegetable packaging experiences? (Benchmarking packaging features and experiences) (RQ2)
- What does multiple-use packaging mean for the stakeholders involved in the fruit and/ or vegetable sector? (RQ1 and RQ2)

To structure the subjects of the project an inspirational look was taken to the products innovation process - 2 (Van Boeijen, Daalhuizen, Van der Schoor, & Zijlstra, 2014). The approach in this project, is linear, instead of circular, because the structure is gone through once. In figure 3, the detailed project approach is presented. The linear design approach is based on the approaches from figure 1 and 2. The circles on the green horizontal centre line are the main subjects, which with sub-categories lead to results and insights, after converging the information.

The analysis is the first phase of the project, and is about understanding the context of the project, in which facts and insights are gathered, and analysed. These insights create criteria, that are translated and used to design the packaging solution in the synthesis phase. Each part of the analyses answers to one of the research questions.

In the first chapter of the analysis phase, literature research is performed to discover facts about the current waste problems. This to substantiate the relevance of this project. Understanding the problems caused by packaging waste is key to do proper research, and to design a packaging solution that has an impact on the current problems concerning packaging.

The following chapter contains the benchmarking of the current fresh fruit and vegetable packaging. This is done to obtain insights into the available packaging and to have a benchmark to compare the new packaging solution with. The features of current packaging are discovered and materials identified. The fruits and vegetables are analysed to make a decision process for one fruit or vegetable. This to narrow the project down, and to be able to do more elaborated research into one fruit or vegetable in the limited time of this project. The selected fruit or vegetable and its packaging are then analysed to discover key insights for the packaging solution.

In the consumer research chapter, the consumer is researched by both literature and interviews. The consumer involvement in sustainability is researched to answer a part of the first research question (RQ1), and the consumers experience with reusable packaging is researched to answer the second research question (RQ2).

After the consumer research other stakeholders in the chain of fruit and/ or vegetable are analysed. This is done by interviews with the stakeholders. The journey is analysed to get familiar with the life cycle chain

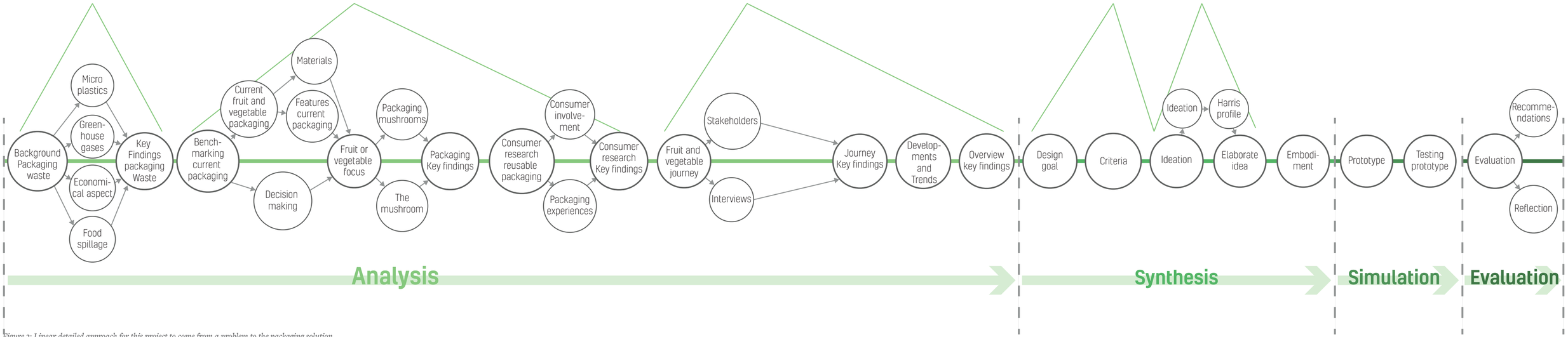


Figure 3: Linear detailed approach for this project to come from a problem to the packaging solution

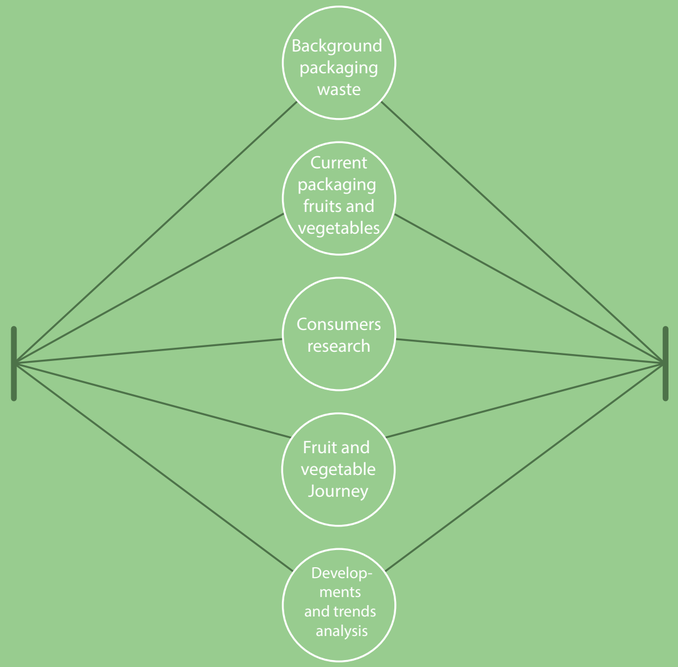
and to get insights into the demands of the different stakeholders concerning fruit and vegetable packaging. The chapter will be concluded with an overview of potential improvements per stakeholder.

The fruit and vegetable journey is performed to gather insights into potential improvements concerning environmental impacts, as to get familiar with the life cycle chain of fruits and vegetables and its packaging.

The next phase of the project is the synthesis phase. In this phase, the findings of the analyses phase are translated into a packaging solution. The combined insights result in the program of demands and wishes (criteria), as a clear design goal that is in line with the main assignment of this project. Ideation is done within the scope of the design goal. From the ideation elaborated ideas are created, from which one is selected by using a Harris-profile. The most promising idea is chosen to be embodied. This is done through a shape analysis and at the end an optimisation. From the 3D model made in this phase, a prototype is made that can be evaluated.

The developed prototype is tested in the simulation phase, this is done by a usability test with consumers. From the test, the design of the prototype is evaluated and recommendations made for further development of the packaging solution.

The last phase of this project is the evaluation phase. In this phase, the packaging solution concept is evaluated, and recommendations for further steps for this concept are noted. This phase is ended with a reflection on the project and a personal reflection.



01 | Analysis

3. Background packaging waste

In background packaging waste, facts about the current waste problem, and predictions of future problems are analysed. An extra focus on plastics packaging is done in this report, because compared to other packaging materials, like paper and cardboard, plastic is a synthetic material, which has an undeniable impact on the environment. The numbers named in this part of the report can be used to predict the potential environmental advantage of the packaging solution. Literature research is done to discover the problems concerning packaging waste. This part of the analysis will partly answer the first main research question (RQ1) described in the introduction of this report. The problem definition will give an answer to the following questions:

- What problems concerning packaging waste are most harmful to the environment?
- What does current packaging contribute to the environmental impact?

3.1 Facts on packaging waste

In the Netherlands, the total amount of waste generated in 2010 was 59,9 million ton of waste, from which 8,8 million tons by the consumer (Rijkswaterstaat, 2013).). In figure 4, the waste divided per sector is illustrated. In table 1 data about the amount of municipal waste is shown as the total amount of household waste. The numbers show a decreasing amount of municipal waste as household waste, with the exception of 2016 in which a slight increase is measured by the CBS (Centraal Bureau voor de Statistiek, 2018a). From the data is derived that till 2014 an increase in separately collected plastic packaging in household waste is measured. A reason could be an increase in plastic packaging material over the years. Another reason could be that people started to sort their plastic packaging waste better, this was achieved by the "Plastic Hero" campaign set up by the Dutch government in 2008 (Effie awards, n.d.). In the year 2014, 1.6 % of the household waste was due to plastic packaging. In the years after 2014, a decrease in separately plastic packaging waste has occurred. This could be due to the set law of forbidding free plastic bags, which was set at the first of January in 2016 (Rijksoverheid, 2016). Another reason could be that consumers buying behaviour is changing, and consumers try to avoid plastic packaging.

The percentage of plastic packaging in household waste is decreased from 1,6 per cent in 2014 to 0,3 per cent in 2016. The objective is to continue the decrease in percentage of plastic packaging in household waste, no assumption based on this data can be made about the percentages in the coming years.

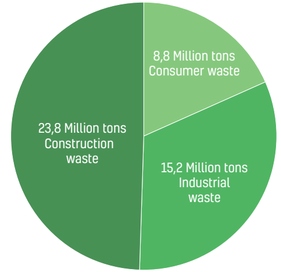


Figure 4: Total waste per sector in the Netherlands in 2010, the total amount of waste was 59,9 million tons of waste

Year	Total municipal waste (1000 ton)	Total Household waste (1000 ton)	Separately handed in plastic packaging (1000 ton)	Separately handed in Paper & cardboard (1000 ton)	Percentage plastic packaging of household waste
2000	10262	8986	2.4	1022	0.0
2005	10408	9158	5.1	1130	0,0
2010	10061	8860	82.5	1125	0.9
2014	9517	8385	130.8	875	1.6
2015	9514	8375	85.1	884	1.0
2016	9519	8420	28.5	854	0.3

Table 1: Presenting data about the total municipal waste, the separately measured household waste ((Centraal Bureau voor Statistiek, 2018a). The separately handed in plastic packaging and separately handed in paper & cardboard data is retrieved from a dataset made by rijkswaterstaat (Rijkswaterstaat, n.d.).

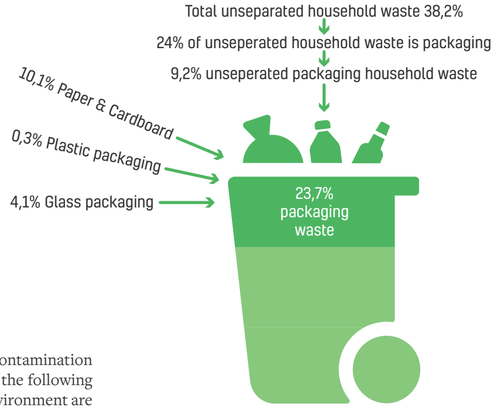


Figure 5: Share packaging material from total household waste in 2016, calculated from the weight (Centraal Bureau voor Statistiek, 2018). The percentages per material are calculated from weight per material, collected data in dataset (Rijkswaterstaat, n.d.). 24 percent of unsorted household waste is packaging materials (Rijkswaterstaat, 2018). The unsorted waste is 38,2 percent of the total household waste in 2016, which means that 9,2 percent of unsorted household waste is packaging waste.

Through data summarized in an online database from Rijkswaterstaat, the total amount of packaging waste by the consumer could be calculated. The percentage of packaging waste in households is 23,7 per cent. In figure 5, the share per packaging material to the consumer packaging waste is illustrated. According to calculations 9,2 per cent of unsorted household waste is due to packaging. According to Rijkswaterstaat (2018), is 32 per cent of unsorted household waste caused by paper and cardboard packaging and 38 per cent caused by plastic packaging. To summarize, plastic, paper and cardboard packaging are the most found unsorted packaging materials from consumers waste.

In 2017, Afvalfonds Verpakkingen found that 73 per cent of all packaging is recycled. Glass packaging had a recycling rate of 83 percent, paper and cardboard 85 per cent, and plastic packaging had a rate of 50 percent. Plastic packaging is less recycled than other materials. According to Hopewell, Dvorak, and Kosior (2009), this is due to economic viability, technical sorting processes, consumer sorting processes, contamination of the materials, and packaging design. In the following chapters, the impacts of plastics on the environment are researched and explained.

This chapter has given insight into numbers about the amount of waste in the Netherlands. From 2014 the share of plastic packaging in separately collected waste is decreasing, while the share of plastics packaging in unsorted waste is higher than other packaging materials.

The relevance of designing the packaging solution is to continue the decrease in the share of packaging materials in the waste stream. The packaging solution could also have a small but positive influence on the total amount of municipal waste.

3.2 Micro plastics

Problems concerning packaging life-cycles are the consumption of fossil fuels, the emission of greenhouse gasses, leakage through landfill and leakage through packaging waste ending up in the natural environment (Brisson, 1993),(Hopewell, Dvorak, & Kosior, 2009). This chapter goes into detail about a relevant problem called micro plastics, which is a result from leakage of plastic waste. Research is performed about what micro plastics are, how they occur and their harms to the environment. Also, a prediction of the future is done concerning the environment, which will be the result when the current plastic situation does not changes. This chapter supports the first main research question(RQ1). Research into the following question is done, "What problems concerning packaging waste are most harmful to the environment?" literature research is performed to get answers to the questions noted in the introduction (3.0 Background packaging waste).

Plastics are synthetic materials and have an impact on the environment. By degradation of plastics, micro plastics are formed. According to the European Commission (2011), micro plastics are small fragments of plastic ranging from 5 mm to 333 micrometres. Micro plastics are divided into primary micro plastics and secondary micro plastics (European Commission, 2011). Primary micro plastics sources are intentionally made for direct use or as precursor to produce other products (Arthur, Baker, & Bamford, 2009). Secondary Micro plastics are formed from the degradation of the larger plastic objects, such as plastic bottles (Arthur, Baker, & Bamford, 2009). Another source of secondary micro plastics is through the digestion by wildlife, which according to an estimation stands for 630 million plastic particles every year, or six tons in plastic mass (European Commission,2011). Micro plastics in the oceans are ingested by marine animals, which accumulates and could end up in the food products of humans (European Parliament, 2018). Micro plastics have been found in multiple food products and drinks, even in tap water.

The Europan Parliament (2018) states, "The effect on human health is as yet unknown, but plastics often contain additives, such as stabilisers or flame-retardants, and other possibly toxic chemical substances that may be harmful to the animal or human ingesting them". Plastics may also contain unintended impurities and contaminants, which could bring unexpected harm to humans and animals ingesting it(Ellen MacArthur et al, 2016).

To get an idea about the size in which micro plastics are released into the environment a paper published by the Ellen MacArthur Foundation was analysed. The leakage of plastics into the environment (especially in the ocean) is 32 per cent of the annual production. This leakage causes the degradation of natural systems (Ellen MacArthur, Waughray, & Stuchtey, 2016). At least 8 million tonnes of plastics leak into the ocean every year, to put this into perspective, this is the same as dumping the contents of one garbage truck into the ocean every minute. According to Ellen MacArthur, Waughray and

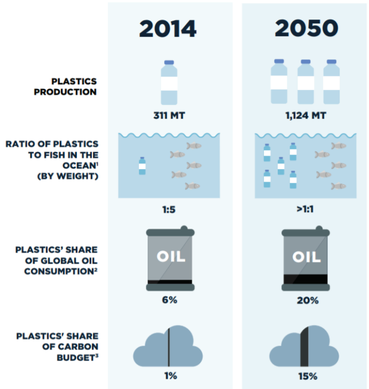


Figure 6: Prediction of Plastic Volume growth, Externalities and Oil Consumption in a Business-As-Usual Scenario (Ellen MacArthur, Waughray, & Stuchtey, 2016)

Stuchtey (2016), if no action is taken it will increase to two contents of garbage trucks in 2030. In 2015, De Waart, De Jong, and Tijs found that 73 per cent of street litter in the Netherlands consists of packaging, which means that packaging are likely to have the biggest share in waste leakage.

The amount of plastics accumulates over time in which plastics degradate into micro plastics. Figure

3.3 Greenhouse gases

6, illustrates the forecast of plastic volume growth, externalities and oil consumption in a business-as-usual scenario (Ellen MacArthur, Waughray, & Stuchtey, 2016). The figure illustrates that the oil consumption will rise up to 20 per cent in 2050. The greenhouse gases emitted in processes concerning plastics are researched in the next chapter. According to Ellen MacArthur, Waughray, and Stuchtey (2016) the greenhouse gas emissions from incineration processes with energy recovery are 14 per cent of the annual waste flow, which is lower than the leakage (32 per cent) and landfill share (40 per cent).

Summarizing, micro plastics will continue to accumulate in the environment by leakage if no action is taken. The accumulation of micro plastics can be decreased by lowering the amount of plastic waste, which could be done by reusing of packaging, and by producing less litter.

In previous chapter "1.2 Micro plastics" it was shortly named that greenhouse gases are emitted by processes concerning plastic packaging. As illustrated in figure 7, plastic production consumed 6 per cent of the global oil in 2014. With the use of fossil fuels, a link can be made with emissions of greenhouse gases. According to Ellen MacArthur et al (2016), the emission of greenhouse gases can be reduced during the use phase of plastics. This can be achieved by extending the life time of the material by reusing the product. In this chapter research is performed into greenhouse gases, to discover; the impacts to the environment, in which life-cycle phases greenhouse gasses are produced and what kind of gases are related to packaging.

Greenhouse gases absorb radiation, which causes temperatures to rise, which results in melting glaciers, rising sea levels, dying cloud forests and wildlife having difficulty to keep up (Nunez, n.d.). According to Ellen MacArthur et al (2016), the rise of greenhouse emissions is caused mostly by the manufacturing of plastic material itself, which includes the extraction of raw materials. Incineration of plastics result in the direct release of carbon, form which by energy recovery part is saved (Ellen MacArthur et al, 2016). Knowing this, it means that if plastic packaging is reused by the consumer fewer greenhouse gases are emitted because less packaging needs to be produced.

Greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and fluorinated gases(Rodhe,1990). In this project, CO_2, CH_4, and N_2O have relevance concerning the packaging sector. According to Rijksoverheid (2019), CO_2 is emitted in the largest quantities compared to other greenhouse gasses, however the greenhouse gasses variate in toxicity (appendix IV C). In appendix IV C, increase and decrease of the tree greenhouse gasses in 2017 are stated.

Plastic products which are exposed to sunlight start a decay process in which greenhouse gasses are emitted (Deweerdt, 2018). In this decay process, secondary microplastics are formed and methane and ethylene are emitted. The impact of methane emissions is 25 times greater than carbon dioxide (Pachauri, The Core Writing Team, & Reisinger, 2008).

The greenhouse gas emissions can be lowered by looking at the processes concerning fruit and vegetables, for example packaging, transport and disposal. In chapter "6. Fruit and vegetable journey", the processes per stakeholder are identified and possible environmental savings stated.

3.4 Food spillage

First chapters were about packaging waste and the problems it causes to the environment. Another aspect is food waste. The consumer can buy fruits and vegetables either pre-packaged or unpackaged. Subjects analysed in this chapter are: The amount of food spillage in the Netherlands, the share in food spillage per sector, and possible solutions for food spillage. Food spillage has influence on the environment and thereby is part of the first main research question (RQ1). The objective of this chapter is to discover how food spillage can be lowered with the design of the packaging solution, and to discover the environmental impact of a fruit and/ or vegetable.

First the difference between "food loss" and "food waste", is made clear (Groentenfruit Huis, 2019). Food loss takes place in the production phase before reaching the consumer. Food waste is defined as food which is meant for consumer consumption, but is not consumed (Wageningen Food & Biobased Research, 2017). In 2017, Wageningen Food & Biobased Research found that the food waste per Dutch habitant in 2016 was between 105 - 145 kilograms, which is calculated with food waste from the industry included. According to Milieu Centraal (2017), 41 kilograms of food is wasted by consumers a year. According to the data from Milieu Centraal and Voedingscentrum (2017), the consumer is responsible for 13 per cent of food waste from the bought waste. In figure 8, a pie chart is shown with the results of a research in Europe into the share per sector in food waste in 2012. Household food waste has the largest share and processing has the second biggest share (Stenmarck, Jensen, Quested, & Moates, 2016). This project is focussed on fruit and vegetables, from the bought fruits 17 per cent is spilled and from the vegetables 19 per cent is spilled (Milieu Centraal & Voedingscentrum, 2017). In figure 9, the percentages of wasted fruit and vegetables are made visual.

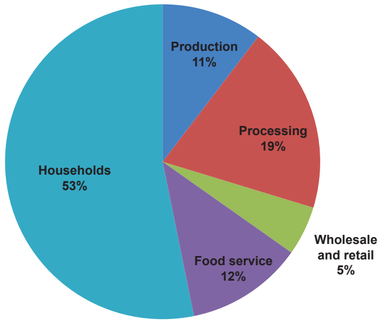


Figure 8: "Split of EU-28 food waste in 2012 by sector; includes food and inedible parts associated with food" (Stenmarck, Jensen, Quested, & Moates, 2016).

Part of the fruits and vegetables are sold pre-packaged, which means they have a predetermined volume of food. This volume may cause food spillage when consumers are not able to buy their desired amount. A solution could be to let consumers always be able to pick fruit and vegetables themselves when doing groceries.

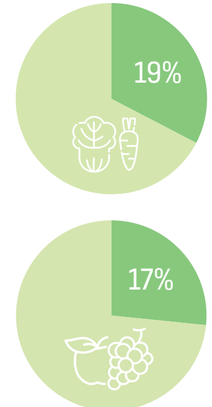


Figure 9: Percentage food waste of fruits and vegetables from the total amount of food waste (Milieu Centraal & Voedingscentrum, 2017).

At supermarkets food is not sold when the quality is not up to standard, or the appearance is not as wished. For example, in the summer of 2018 tomatoes were rejected by the supermarket, because they did not have the right size (Van Diemen, 2018). If less products are rejected, less production is needed, and fewer greenhouse gases in the production stage of fruit and vegetables are emitted.

Pre-packaging of fruit and vegetables has its benefits. A packaging can extend shelf-life, maintain or increase the quality and safety of the content (Marsh & Bugusu, 2007). For some food products packaging is more efficient than no packaging, this consideration depends on the features of the fruit or vegetable itself and on the energy and time needed to get the product from the

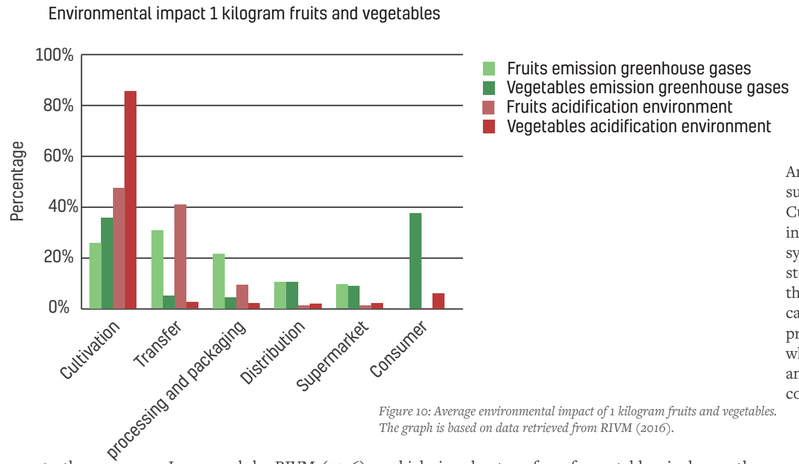


Figure 10: Average environmental impact of 1 kilogram fruits and vegetables. The graph is based on data retrieved from RIVM (2016).

grower to the consumer. In research by RIVM (2016), the environmental impact per process of 1 kilogram of fruits and vegetables is researched. In figure 10 a graph is illustrated of the share of greenhouse gas emissions and acidification per life cycle phase. From the greenhouse gas emission share is the kilograms carbon dioxide equivalent shown and for the acidification of the environment the kilograms sulphur dioxide equivalent is shown (RVIM, 2016). In this research by the RIVM averages of multiple fruits and vegetables are used, the shares in life cycles phases vary per fruit and vegetable. The cultivation process has the biggest impact, because of used machinery to prepare the land, grow the fruits and vegetables, and for the final harvest. The impact of transfer is higher for fruits, which is due to the burning of fossil fuels by transport overseas (RVIM, 2016). Most vegetables are grown in the Netherlands, which is why transfer of vegetables is lower then fruits. The distribution of fruits and vegetables have almost the same share in environmental impact. The greenhouse emission share of vegetables are higher at the consumer phase because vegetables need to be cooked before eaten, at which energy is consumed. In this project, the reusable packaging solution could make a positive contribution to the processing and packaging, distribution and supermarket life-cycle phase of a fruit and/ or vegetable.

A balance needs to be found between shelf time of a food product and the need for a packaging. The packaging should serve the food product by maintaining or improving the quality of the content inside over time, to prevent food spillage.

Another insight into preventing food waste is to make supply and demand of fruit and vegetables more efficient. Currently there are systems, which measure the stock in supermarkets and order the needed products. This system combined with big data can predict the needed stock. By recording buying behaviour of consumers the supply and demand can be more sufficient. This can prevent food waste and prevent unnecessary production. The shelf time can be shortened as well, when the supermarket knows what needs to be ordered, and when certain amounts are sold or know when the consumer does its groceries.

3.5 Economical aspect

In this chapter the costs involved with the disposal of waste is analysed. This to discover were costs can be saved and what the current situation is around packaging costs. Paying for a packaging is a consumer experience, which for example is dependent on price. The economical aspect is analysed to see whether consumers are willing to pay more for a more sustainable packaging solution. This chapter analyses the economical aspect of the packaging waste collected by a disposal company as the costs concerned with litter on the streets.

In 2017, Hall wrote " Packaging - much of it single-use food wrapping - has created a rubbish problem that now pollutes every corner of the world". Packaging have become a one time use product, this can also be due to ability to produce packaging for a relatively low price and in large amounts. One of the reasons why we do not reuse a packaging is that the supermarkets are not adapted to reuse of packaging. This statement is substantiated in a research paper by Beitzen-Heineke, Balta-Ozkan, and Reefke (2017), in which is stated that packaging are used for a short time, and that the food industry should strive for reusable products. Currently, grocery stores sell mostly fruits and vegetables with single use packaging. Another reason for not reusing packaging could be that we can afford to only use the packaging once.
One of the factors that influences the attitude of consumers is price, according to Martinho, Pires, Portela, and Fonseca (2015). The question could be asked if people still throw away a packaging after one-time usage, if the packaging is more expensive. In research into the willingness of people to pay more for a product packaged in a sustainable wrap, was found that 19% of the consumers are willing to pay more and 63% would consider it. This research shows that people are open minded for the suggestion to pay more for sustainable products.

As mentioned in the chapter "1.1 packaging waste" and chapter "1.2 micro plastics", there is separated waste, unsorted waste and litter. A food product goes through multiple processes from the grower to consumer, with each process value is added. When the packaging and or the food is disposed of the value is lost, and it costs money to dispose of. It can be argued if the value of the packaging is already lost after the contend is taken out, because the main objective of protecting the food is finished. Each kilogram unsorted household waste that is not disposed of saves the Dutch community 0,069 euro (Rijkswaterstaat, 2017). Transport and tax is not included in this price. The unsorted waste is likely to be burned. In short, every kilogram waste saved saves money and greenhouse gases. If waste is better sorted by the consumer, less waste is burned, and money is saved.
Other costs which can be saved are costs concerning preventing and collecting of litter. The Dutch government invests in keeping the environment clean. In 2010, the costs to keep the environment clean from litter costs 250 million euro (de Waart, de Jong, & Tijs, 2015). This is almost 15 euro a person. If less or no litter is produced it saves money as the environment. In chapter "1.3 Micro plastics" the impacts to the environment of plastic litter are explained.

Summarized, an economic benefit could be achieved when less waste is produced. This could be done by using less new packaging. A way to use less packaging is to reuse packaging. Better sorting of waste and preventing litter by the consumer it is possible to save money as well.

3.6 Key findings packaging waste

- Buying behaviour is changing, less plastics packaging is found in the household waste. (Trend)
- Consumers are willing to do and pay more for sustainable products. (Trend)
- Pre-packaged food products have a set volume of food, which not always complies with the needed amount by the consumer. Put the consumer in charge of taking the desired volume of food.
- A balance need to be found between shelf life and the need for packaging.
- Smart systems with big data analyses can prevent food and packaging waste.
- Supermarkets are not adapted to reuse of packaging, most of the packaging are single-use products.

4. Benchmarking current Fruit & Vegetables packaging

The following chapters are about getting an image of the current fresh fruit and vegetable market. All different kind of packaging are mapped and analysed on material and features. This is done to learn from what has been done and to have a reference for the consumer packaging experience part of this project. This part of the report is called benchmarking, because the new packaging solution must have a reference on which to improve, to do this insights in the current fruit and vegetable sector are researched. The materials of the packaging are researched to discover current used packaging materials. The question asked in chapter “2.0 Approach”, “What does the current packaging of fruit and vegetables contribute to the environmental impact?”. This is researched by discovering the materials of the packaging.

Nearly all fruit and vegetable packaging from two supermarkets are analysed. From this analysis a decision is made for a certain fruit or vegetable. This fruit or vegetable will be the focus in this project and be the carrier for the embodiment of the packaging solution. The focus on one fruit or vegetable is done to limit the project, because every fruit or vegetable has its own characteristic to which a packaging needs to be adapted. After the focus is made, research into the fruit or vegetable is done to discover the demands of the vegetable for packaging. Next, the packaging of the chosen fruit or vegetable is researched a by doing desk as field research, to find packaging beyond the packaging found in two supermarkets. The chapters are concluded by summarizing the key findings.

Questions raised before focussed on one fruit or vegetable:

- Which packaging are available at the fresh fruit and vegetable sector in the supermarket?
- What are the main purposes of packaging?
- What materials are used in packaging?

Questions raised after the focus is made:

- What demands of the vegetable must be met in the packaging solution?
- What packaging of that fruit or vegetable is available in the market?
- Which rules has the government set-up around packaging?
- Which packaging of that type of fruit and vegetable is designed first? And why is it designed as it is?

4.1 Packaging market

In this chapter an overview is given of packaging from the fresh fruit and vegetable sector. This is done to see what kind of packaging are available. On the next page an overview of al the different packaging collected is presented. The numbers of the packaging are connected to the list of identified different packaging below. The decision is made to take nearly all available fruit and vegetable packaging from two supermarkets, this to limited the search. The following packaging are identified:

- Cardboard trays with plastic seal foil (1)
- Cardboard basket with a plastic bag (5, 23)
- Loose Plastic bag (24) (not pre-packaged)
- Netting (9)
- Plastic baskets with and without lids (3, 4, 6, 12, 13, 17)
- Plastic basket wrapped in a plastic bag (2, 14)
- Plastic basket wrapped in foil (7)
- Plastic basket with top seal (8, 16)
- Plastic bucket (15)
- Sealed plastic bag (10, 19, 20, 21, 22)
- Vacuum sealed in foil (18)
- Wooden tray vacuum wrapped in plastic (11)

Multiple kind of packaging are available, and for some fruits and vegetables multiple packagings offered. For example, for small tomatoes four different packaging were identified.

What is the function of packaging?
It is described by Kirwan, Coles, & McDowell (2003), that the definition of packaging and its function depends on the strategy with which the packaging is designed. The strategy in this project is: ''Packaging assists the preservation of the world's resources through the prevention of product spoilage and wastage, and by protecting products until they have performed their function" (Kirwan, Coles, & McDowell ,2003). This strategy agrees with the assignment stated in chapter "1. Introduction". To fulfil a strategy the packaging can poses one or more of the following functions, according to Kirwin et al. (2003):

- Containment
- Protection
- Preservation
- Information
- Convenience
- Presentation
- Brand communication
- Promotion
- Economy
- Environmental responsibility

In the image on the next page some of the functions can be identified.

4.2 Packaging features

To learn from used packaging features, the packaging on the previous page are analysed. The identified features are analysed on; their functionality, their potential functions (chapter “4.1 Packaging market“), and reuse potential. In this chapter reference is created for the main research question 2 (RQ2): What are the consumers current fruit and vegetable packaging experiences? (Benchmarking packaging features and experiences). Further in the report a consumer research into packaging experiences is performed in which the experiences with certain packaging features are researched. The features are ordered by category and used as reference in the design of the packaging solution that is designed in the synthesis phase.

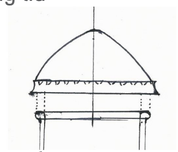
Strengthening

Strengthening structure on the side

Packaging functions: protection, economy, environmental possibility.

A structure in the side walls makes it stronger, while using less material. The advantage is the use of less material.

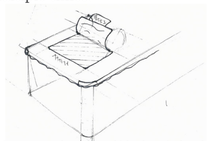
Reopening lid



Click expansion seal

Packaging functions: Containment, Convenience, Preservation

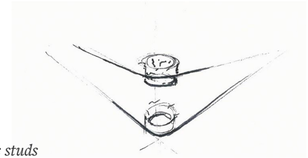
The bottom and the lid of the container are held together by clicking the bottom half into the lid. A disadvantage is that the upper half can eject itself when the lower half of the container is dented or crushed. The packaging is resealable multiple times.



Flexible plastic top seal on a solid plastic basket

Packaging functions: Containment, Convenience, Environmental possibility, Presentation, Preservation

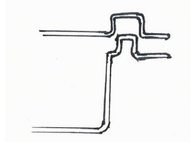
Using a plastic top seal which is melted onto to plastic basket saves plastic in comparison with a hard plastic lid (chapter “4.3 Packaging materials”). The seal is resealable, which is convenient in storing of fruits and vegetables, and in reuse of the packaging. Also, the top seal is more airtight than a hard plastic lid.



Press studs

Packaging functions: Containment, Convenience

Designed to keep the lid on the bottom half of the container without sealing it airtight. The advantage of press studs is that the connection stays strong after being resealed multiple times. Under pressure, the packaging itself can tear because of the strong connection press studs make.

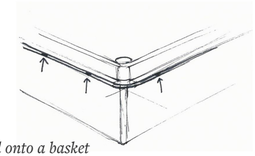


U-shape lid seal

Packaging functions: Containment, Convenience, Protection, Preservation

The top and bottom half of the packaging is held together by a double U-shape edge. The seal is strong, even when the packaging is crushed or dropped. The seal adds strength to a packaging. The seal, takes more time to seal than for example press studs. The U-shape seal can be resealed multiple times.

One time usable lid



Welded lid onto a basket

Packaging functions: Containment, Preservation, Protection

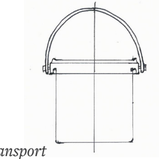
The lid is spot welded onto the basket. An advantage of a welded packaging is that it can function as a security feature, because the welds need to be broken to take the fruits or vegetables inside. A disadvantage, The weld can break when a packaging is dented or crushed together, for example during transport. Not a reusable packaging feature.

Foil around the complete packaging

Packaging functions: Containment, Convenience, Preservation, Presentation

Using foil around a packaging instead of a lid saves material (chapter “4.3 Packaging materials”). The top seal is more airtight than a hard plastic lid. Instead of a foil, a sealed plastic bag is used as well in some packaging. The foil does not protect the contents of the packaging from forces from above, for example, when stacking of packaging. Not convenient in reuse.

Convenience in transport

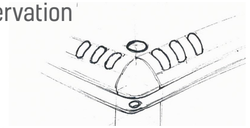


Lever for transport

Packaging functions: Convenience, Presentation

The lever gives an extra experience to the consumer, he or she can carry the packaging in a more handy and different way than other packaging. It is also visually different than other packaging. It can be argued if a bucket is recognisable as a food packaging. The lever feature can be reused multiple times.

Preservation



Air holes

Packaging functions: Preservation, Presentation

In the plastic lid or bottom half of the packaging air holes can be made. The air holes can be in curvatures or on flat surfaces, while still providing protection. Fresh air can reach the food to preserve the fruits and vegetables.

Multiple packaging features were identified from the selection of packaging. Not every feature is designed to be reusable. Currently, al of these packaging and packaging features are used one time, while some features are designed for reuse. An insight from analysing the features is that some packaging may be over engineered. The packaging may not need some of the features if they are not reused. The identified features are used in table 4, to organise what packaging has which features, this to discover packaging insights. The packaging features are also used as reference in the design of the packaging solution in the synthesis phase.

4.3 Packaging materials

The packaging material are researched to discover currently used materials, and to have a reference for the new packaging solution.

A bigger focus is laid on plastic materials, because most packaging collected in the fresh fruit and vegetable part of the supermarket are made of plastic. Also, because of the environmental issues caused by leakage of plastic packaging.

From the packaging image shown on page 20, an overview is made showing the type of fruit or vegetable, the material, the volume of the packaging and the weight of the packaging (table 2). From the table can be deducted that some packaging use multiple materials. It can be seen that the usage of a top seal or foil around the packaging saves weight, which means less material is used. By saving material, the greenhouse gas emission in production are lower.

From the 24 packaging a selection of 16 was made. Single packaged vegetables in a plastic bag are excluded, as are the small carrots.

From the identified materials, a rough overview is made showing the material properties related to packaging (table 3). In multiple packaging a combination of materials is used to get the desired functions. The function does not only depend on material choice. A packaging is the balance between performance, quality, cost, and value for money (Kirwan, Coles, & McDowell ,2003). From which the material choice has influence on every aspect. A side note, packaging materials often consist of multiple layers of materials, which can cause difficulties in separating of the packaging for recycling (chapter “6.7 The disposal company”). Materials have a better rate of recycling when handed in separately.

Multiple foil materials are available for food packaging, all with different properties and functions. From the materials in table 3, the plastics are also available in foils. The properties of foil materials can variate from the rigid plastic properties. The different foils are not further analysed.

An important note about polyvinyl chloride is the toxicity. Polyvinyl chloride is made by polymerisation of vinyl chloride, the chloride content creates environmental problems when incinerated by the emissions of dioxins. Dioxins are harmful for the environment, but dioxins are also carcinogenic (Vinyl Council Australia, n.d.). Dioxins are considered highly toxic. Because of the toxic of vinyl chloride, it brings dangers in transport as well. Because of the dangers in production of Polyvinyl chloride, it is avoided in the design of the packaging solution.
In appendix IV A, more information about the different plastics and cardboard is presented.

To get further insights in fruit and vegetable packaging this chapter and the previous chapter are combined in table 4. Every packaging is also judged on look, feel and behaviour of the packaging when pressure is applied by hand in a vertical - and a horizontal direction. The packing is also flexed, by grabbing both sides of the packaging and turning the sides in opposite direction at the same time. This is done to get to know the materials, the features and functions of the packaging. The last category of table 4 are gathered insights from the packaging. These insights are either packaging specific or general insights that can be used as key insights or demands for the packaging solution.

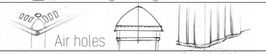
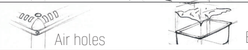
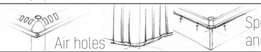
Table 2: Fruits and vegetables and their packaging. The table shows the fruit or vegetable with its packaging, the material, the volume and the weight of the packaging.

Number	Fruit/ Vegetable	Package	Material	Volume (ml)	Weight (gram)
1	Apples	Tray + vacuum seal	Carboard tray + PVC foil		15
2	Apples sweet	Basket + plastic bag	PP + PP/PE bag	2000	17
3	blueberries	Basket	R-PET	360	17
4	Grapes	Basket + lid	R-PET	1350	20
5	Kiwis	Tray in plastic bag	Cardboard + PP/ PE bag		25
6	Mushrooms	Blue basket + lid	PS	900	17
7	mushrooms	Green basket + foil lid	PS + PVC Foil	900	11
8	Mushrooms pre-cut	Bakset + foil top	PET + PP/PE seal on top	800	19
9	Onions	Netting	PE		4
10	Peppers	Plastic bag	PP/PE bag		3
11	Shallots	Tray + vacuum seal	Wood tray + PVC foil		16
12	Small tomatoes	Basket + lid	PET	625	18
13	Small tomatoes	Shaker	PET	440	15
14	Small tomatoes	Black basket + plastic bag	PS + PP/PE bag	1000	11
15	Small tomatoes	Bucket	PP	690	32
16	Strawberries	Basket + foil seal	R-PET + PP/PE seal on top	1400	19

Table 3: Packaging materials and their properties, based on information retrieved from Marsch, and Bugusu (2007), and Kirwan, Coles, and McDowell (2003). The toxity is based on potential toxicity in production and when incinerated.

Material	Available as foil	Stiffness	Flexibility	Moisture resistance	Gass barrier	Transparancy	Toxity
Aluminium	+	++	+	++	++	-	-
Cardboard	-	+	+	-	-	-	--
Glass	-	++	-	++	++	++	--
Paper	-	-	++	-	-	-	--
Low Density Polyethylene (LDPE)	+	-	++	++	-	+	+
High Density Polyethylene (HDPE)	+	++	+	++	-	+	+
Polyethylene terephthalate (PET)	+	+	+	++	++	++	+
Polypropylene (PP)	+	++	+	++	+	++	+
Polystyrene (PS)	+	++	-	+	+	++	+
Polyvinylchloride (PVC)	+	++	+	++	++	++	++

Table 4: Analysis of the collected fruit and vegetable packaging by material, functions, features.

Fruit or vegetable	Packaging describtion	Packaging material	Feel of the packaging	Packaging functions	Packaging features	Insights
Apples	Tray + vacuum seal	Cardboard tray + PVC foil	The packaging with the apples in it, feels rigid, because of the tight seal that keeps the apples against eachother.	- Containment - Protection - Presentation - Preservation	 Foil around packaging	The fruit or vegetable inside the packaging can give strenght to a packaging
	Basket + plastic bag	PP + PP/ PE bag	The basket is not flexible and cracks when deformed. The plastic bag feels flexible, but has a certain stiffness.	- Containment - Protection - Presentation - Preservation	 Strengthening structure	Strengthening structure gives rigidness to a packaging with a thin wall thickness, but without a lid, it flexes and the upper edges crack relatvely easily
Blueberries	Basket with lid attached	R-PET	The basket feels rigid and protective, although the rigidness, the basket can be flexed without cracking.	- Containment - Protection - Presentation - Convenience	 Air holes, Reopening lid, and the lid is attached to the basket	Reopening lid with an attached lid, is a convenient feature for products that are not eaten in one time and are therefore convenient for a reusable packaging.
Grapes	Basket with lid attached	R-PET	Thin wall thickness, while the packaging has a relatively large volume. It is flexible, but the material cracks when is force is applied.	- Containment - Protection - Presentation - Convenience	 Air holes, Reopening lid, and the lid is attached to the basket	A press studs connection can be stronger then the packaging, the packaging then tears before the press studs let loose.
Kiwis	Tray + plastic bag	Cardboard + PP/ PE bag	The cardboard is strong and rigid enough, in this shape to contain the kiwis, but offers little protection to forces.	- Containment - Brand communication - Presentation	 Air holes, Bag around the carboard tray	
Mushrooms	Blue basket + Lid	PS	The packaging feels rigid in verticle direction. The material is brittle and cracks easily. Easily deformed by an horizontale force.	- Containment - Protection - Presentation - Preservation	 Air holes, Spot welded lid, and strengthening structure	When a packaging cracks relatively easy when flexed or when pressure is applied to it, it is not fit to be reused as food packaging.
	Green basket + foil wrapping	PS + PVC foil	The green basket feels rigid and the material is brittle. The foil stretches and folds easily around the packaging.	- Containment - Protection - Presentaion - Preservation	 foil wrap around the plastic basket, and strengthening structure	
Mushrooms pre-cut	Basket + top seal foil	PET + PP/ PE top seal	The basket is rigid, but does not feel brittle. The top seal is resistant from forces from above. It is a single use top seal.	- Containment - Protection - Presentation - Preservation	 Single use top seal, and strengthening structure	
Onions	Netting	PE	Flexible netting. The netting is strong, to rip the netting force is needed, maybe even scissors. Netting feels sharp.	- Containment - Presentation - Convenience - Economy		A netting does not give protection against contamination.
Peppers	Plastic bag	PP/ PE bag	The plastic bag has a certain stiffnes to it, it forms in its owns way when flexed. Air is trapped inside the packaging.	- Containment - Presentation - Convenience - Preservation		If air is trapped inside the packaging it is less efficient in transport.
Shallots	Tray + vacuum seal	Wooden tray + PVC foil	The wooden tray feels rigid and strong. It gives a feeling of a fresh food product. The PVC foil is thin, flexible, and can be stretched.	- Containment - Presentation - Preservation - Brand communication	 Foil wrapping around the tray	The wooden tray gives the feeling of a fresh food product.
Small tomatoes	Basket + Lid	PET	The packaging feels rigid and protective. The lid gives strength. Upper edges of the basket break when the packaging is flexed.	- Containment - Presentation - Protection - Preservation - Convenience - Economy	 U-shape lid seal, and strengthening structure	The packaging is designed to be stacked. The u-shape lid seal is made for reuse.
	Shaker	PET	The packaging feels rigid and protective, not brittle. The cylindrical shape gives strength to the packaging.	- Containment - Presentation - Protection - Convenience	 Click expansion seal, and strengthening structure at the bottom.	In some packaging the presentation and convenience is more important than economy and transport efficiency
	Black basket + plastic bag	PS + PP/ PE bag	The plastic basket feels vunerable, brittle and has little strenght. The basket makes cracking sounds with every handling. The bag is less flexible than PVC foil.	- Containment - Presentation - Protection	 Strengthening structure, and plastic bag around the basket.	The sound a packaging makes in use influences the packaging experience. [Sound design is not further analysed in this report]
	Bucket	PP	The bucket feels rigid and protective and has a relatively thick wall thinkness. The material does not crack when flexed. The shape gives strenght to the packaging.	- Containment - Presentation - Protection - Convenience - Preservation	 Lever for transport, and u-shape seal.	
Strawberries	Basket + top seal foil	R-PET + PP/ PE top seal	The basket feels rigid and protective. It has medium flexibility. The tension of the top seal makes stacking possible.	- Containment - Presentation - Protection - Convenience - Preservation - Economy	 Reusable top seal, and strengthening structure	A top seal can also be applied at the supermarket, which enables the consumer to take their own desired amount of fruit or vegetables

4.4 Fruit and vegetable focus

In the previous three chapters research is performed into currently sold fresh fruits and vegetables packaging. As mentioned in chapter "1.0 Approach" a focus will be laid on a type of fruit or vegetable. The fruit or vegetable that results from the comparison in this chapter, is the carrier to which the packaging solution is adapted. The information to which the fruits and vegetables are compared is retrieved through literature research.

Criteria
To make a decision for a type of fruit or vegetable, the following criteria was noted to compare the fruits and vegetables with:

- Shelf life of the fruits and vegetables unpackaged as pre-packaged

The fruit or vegetable with the shortest shelf life is considered most challenging. It is also taken into consideration if a fruit or vegetable needs to be stored inside the fridge, because these consume more energy to be kept fresh.

The criteria of shelf life was chosen because of the following reasons:

- Packaging waste, Fruits and vegetables with a shorter shelf life could result in more packaging waste, due to passing the expiration date.
- Food spillage, Food and vegetables need to be consumed in a shorter period of time before they decay. This could result in food spillage at the consumer and food waste at the supermarket.
- Packaging demands: To extend shelf life a packaging could play a role. It is assumed that short shelf life fruits and vegetables have more packaging demands.

	Unpackaged		Packaged and/ or stored to maximize shelf life	
	shelf life on the counter (Days)	shelf life in fridge (Days)	shelf life on the counter (Days)	shelf life in fridge (Days)
Apples[1]	3 - 7	14 - 28	14 - 28	28 - 56
Blueberries[2]	1	1 - 3	2 - 3	5 - 10
Grapes[3]	3 - 4	7	3 - 5	5 - 10
Kiwis[4]	3 - 7	7 - 21	7 - 14	7 - 21
Mushrooms[5]		3		7 - 10
Onions[6]	62	7	28 - 42	28 - 56
Shallots[6]	62	7	28 - 42	28 - 56
Small tomatoes[7]	7		7	14
Strawberries[8]	1	1 - 3	1 - 2	5 - 7

Table 5: shelf life of fruits and vegetables without packaging, based on data retrieved from Voedingscentrum (n.d.). Other data retrieved from 1 Eat By Date (n.d.-a), 2 Eat By Date (n.d.-n), 3 Eat By Date (n.d.-c), 3 Eat By Date (n.d.-d), 4 Eat By Date (n.d.-e), 5 Eat By Date (n.d.-f), 6 Eat By Date (n.d.-g), 7 Eat By Date (n.d.-h).

In table 5, the different shelf life's of the fruits and vegetables are presented. The table is divided in shelf life unpackaged and pre-packaged, and/ or properly stored. The presented shelf life's are considered from when they are bought by the consumer. The shelf life days can vary, because the fruits and vegetables may be purchased, stored and prepared in different ways, this all influences the expiration date (Eat By Date, n.d.). According to the shelf life's presented in table 5, the strawberries, blueberries, and mushrooms have the shortest shelf life. Both strawberries and blueberries can be kept outside the fridge for a day without packaging and 2 to 3 days packaged outside the fridge. Mushrooms cannot be stored outside the fridge either unpackaged or pre-packaged. The shelf life for storing inside the fridge without packaging is the shortest for tomatoes, less than one day. Strawberries and blueberries have the same shelf life and mushrooms are fourth shortest with 3 days. The strawberries have the shortest shelf life when properly stored inside the fridge, second blue berries and grapes and fourth mushrooms.

Decision making
Because the mushrooms can not be stored outside the fridge and have a relatively short shelf life inside the fridge as well, they are chosen as carrier for the packaging solution.

The company Kordaat Product Design with whom this project started, had an interest in mushrooms packaging. This played part at the beginning of the project into which direction the project was sent. However, the research in the previous chapters was done to get to know the fresh fruit and packaging sector as to research if mushrooms are a challenging vegetable to focus the project on, which shortly proven to be.
Conclusion
To summarize, the mushrooms have the shortest shelf life outside the fridge, as a relatively short shelf life inside the fridge. The results from the fruits and vegetables shelf life comparison in combination with the preference of the company with whom this project started, it is concluded that the mushroom is the vegetable to which the packaging solution will be adapted.

Discussion
The decision making for a fruit or vegetable is performed using one criterion. This decision was made because of the lack of found objective information to create other criteria. First, the decision making was based on packaging and carbon dioxide footprint. The data for these criteria was found untrustworthy, and incomplete. This because not all life cycle specifics were covered in this carbon dioxide footprint value. The company with who this project started had done projects with multiple growers and supermarkets, but none of the projects was done for the mushroom. At the start of the project, possible fruits and vegetables were discussed, and the mushroom came forward as an interesting vegetable for this project. To consider if the mushroom was interesting for this project, an objective decision process was set up. If more time was available, more criteria could be set to decide for a fruit or vegetable. The sources used to base the decision making on were not research papers, but information from organisations who advise consumers on how to store their food. If more time was available tests into shelf life's of the fruits and vegetables could have been performed. The mushroom, is used as the carrier for the packaging solution, but the packaging solution may be made adaptable to other fruits and vegetables as well. It can be considered that every fruit or vegetable packaged has an environmental impact.

4.5 The Mushroom

Figure 13: The chestnut mushroom, retrieved from Whitmuir Organics (2019).

Figure 12: The white mushroom, retrieved from The Mushroom Council (n.d.).

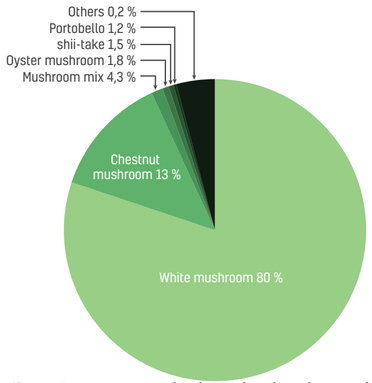


Figure 11: Percentage per type of mushrooms form the total amount of sold mushrooms in Dutch supermarkets in 2009, based on data retrieved from Van den Berg and Schutter (2010).

The mushroom, an analysis is performed into the mushroom, to prevent food spoilage and wastage as described in chapter "4.1 Packaging market" and chapter "3,4 Food spillage". The reusable packaging solution will be adapted to optimally package the mushrooms, which is why research into the mushroom is performed. In this chapter the following questions are answered:

- Which are the most sold mushrooms in the Netherlands?
- What influences the quality of the mushrooms?

There are multiple types of mushrooms grown in the Netherlands. To narrow the project, the focus is laid on the mushroom most sold in the Netherlands. According to Van den Berg and Schutter (2010), the white mushrooms have the biggest share in total mushroom sales in the Netherlands in 2009 (Figure 12). The chestnut mushroom have the second biggest share (figure 13). In figure 11, the percentages of types of mushrooms sold of the total mushrooms sales in the Netherlands in 2009 is presented. Because of the large difference in sold mushrooms between white mushrooms, chestnut mushrooms and the other type of mushrooms, it is concluded to adapt the packaging solution to the white mushroom and the chestnuts mushroom.

Influences to the quality of the mushroom

The quality of the mushroom is determined by looking at the following qualities: browning, softening, cap development, different flavour and secondary mold growth (Kim, Ko, Lee, Park, & Hanna, 2006). However, mushrooms lose quality fast after being harvested, this is caused by storage at ambient temperatures ,moist levels and the overall structure they possess (Oliveira, Sousa-Gallagher, Mahajan, & Teixeira, 2012).

Mushrooms are exposed to different temperatures and humidity levels, because of transport and storage at multiple stakeholders. In research by Oliveira, Sousa-Gallagher, Mahajan, and Teixeira (2012), it was found that the optimum temperature to store mushrooms is between 0 and 5 degrees Celsius, in these temperature sliced mushrooms have a shelf life between 4 and 7,5 days in an optimum packaging. For uncut mushrooms it is assumed the shelf life is longer than 7,5 days at those temperatures.

In 1993, Burton and Noble found that the quality of mushrooms is depended on bruising by mechanical damage. In some cases bruising of the mushrooms have already taken place inside the packaging. The chestnut mushrooms are likely to be less sensible to bruising because of the more firm flesh. If mushrooms are browning they look less attractive, which can end in mushrooms ending up as food waste.

The humidity levels inside the packaging are important to regulate, to maintain the quality of the mushrooms when storing them. According to Mahajan, Oliveira, and Macedo (2008) high relative humidity levels can provoke the following to mushrooms:

- Dark spots
- Brown stalks
- Non-regulated mycelia growth

Low humidity levels can provoke:

- Weight loss
- Undesirable structural changes
- Brown heads

Not only humidity levels have influence on the quality of the mushroom, CO2 levels have influence as well (Lin et al., 2017). In research by Lin et al. (2017), was found that high carbon dioxide levels have positive effect on flavour and quality in storage of white mushrooms. This research shows the dependency of the mushrooms on carbon dioxide levels. This could mean that the air holes in the blue mushroom packaging have the function to control carbon dioxide concentration levels, but also to control humidity levels inside the packaging.

In appendix VII more information about mushrooms is presented.
In the next chapter, the properties of the mushrooms are compared to packaging features of currently sold mushroom packaging.

To summarize, to maintain the quality of the mushrooms it is important to find the sweet spot in climate level inside the packaging. The mushrooms are vulnerable to mechanical damage (pressures), temperature, humidity levels, and carbon dioxide concentrations. These properties are taken into consideration in the design of the packaging solution.

4.6 Benchmarking mushroom packaging

In this chapter, the current mushroom packaging are analysed to create a benchmark for the packaging solution, but also to get to know the used features, and to see how the desired shelf life demands of mushrooms are incorporated into current mushroom packaging. Most packaging are collected by visiting multiple supermarkets and marketplaces, other packaging are found through desk research. Objective data of the packaging is researched, like materials and packaging features, but also a subjective view on the collected packaging is performed. This to discover the provoked thoughts when using the packaging. In appendix VII, the objective data and subjective view per packaging is presented.

Supermarket mushroom packaging

The mushroom packaging in figure 14 and 15, are collected from different supermarkets. Most of the packaging presented are chestnut mushroom packaging, although multiple packaging are used for white mushrooms as well. From the blue basket with the transparent lid multiple packaging were found with different wall thickness's. It was experienced that the packaging with thicker wall thickness's are more sturdy, and crack less easy. All the mushrooms were found at the fruit and vegetable department inside the refrigerator. At most supermarkets, the fruits and vegetables section is the first stage for the consumer at the supermarket. If the fruits and vegetables are not kept separate, they will be at the bottom of the shopping card.

Figure 14: Mushroom packaging collected at supermarkets

Food market mushroom packaging
Mushrooms are sold at the food market in a different way than most supermarkets. To analyse the marketplace, it was visited and packaging bought. To determine the material of the collected packaging the table in appendix IV B was used.

At the food market pre-packaged mushrooms were sold in the blue basket with transparent lid, and unpackaged mushrooms in the bags presented in figure 16. Unpackaged mushrooms were presented loose in blue crates (figure 16). The filling of the packaging was either done by the consumer or market vendor.

Figure 15: Mushroom packaging collected at supermarkets

Figure 16: White mushrooms stored and presented at a market booth

Packaging found through desk research

Figure 17: A kit the grow mushrooms from the packaging.

In figure 17 above, a kit is presented that enables the consumer to grow mushrooms from the box (Back to the roots, n.d.). The packaging is made of cardboard, and it has a lever for convenience for the consumer. It also has the ability to open the front of the packaging to grow the mushrooms out of. The mushrooms have to grow, which means the packaging has a longer useful life time, compared to ready to eat pre-packaged mushroom packaging.
In appendix VII B, more mushroom packaging found through desk research are presented.

Insights from mushroom packaging research
From the analysed packaging it is concluded that the baskets are made strong to protect the mushrooms from mechanical damage. Some packaging was found more flexible than the others, which was due to the material, not the shape. The packaging manufactured from Polystyrene(PS) cracked relatively easy, this could be due to the material properties as mechanical properties of the packaging design. The packaging made from Polyethylene terephthalate(PET) felt stronger and was more flexible. The Polyethylene terephthalate packaging flexed back at the same level of deformation that was applied to the polystyrene packaging.

In chapter “4.5 The mushroom”, it is concluded that the quality of the mushroom is also depended on CO2 concentrations and humidity levels. All The basket packaging had a bottom structure for moist, this to prevent mushroom from touching the moist. The basket packaging with a solid lid has air-holes in the lid to regulate CO2 levels and humidity levels. The mushrooms inside the bag had no air-holes and in those packaging the moist could be seen on the mushrooms as on the inside of the bag, while in packaging with both air-holes and a bottom structure less moist is stored inside the packaging and the mushrooms were more dry. From the analyses in chapter 4,5 The mushroom” and the analyses in this chapter it is concluded that the quality of the mushroom inside the packaging benefits from air-holes and a bottom structure.

The transparency of Polyethylene terephthalate packaging was found to be better than the other packaging materials, while in the chapter “4.3 Packaging materials” the level of transparency of the two materials was the same.

Paper and cardboard are both widely used packaging materials. These materials give the mushrooms a fresh appearance. The paper bag became soft after contact with moist, this influences the properties of the material. The influence of moist on paper and cardboard limits the reuse potential of the material. In the synthesis phase, the materials are reviewed to see which material fits the packaging solution best.

4.7 Design thoughts behind the iconic blue mushroom container

What is the reason of being, and what are the reasons behind the design of the blue mushroom container were the main questions asked in this part of the report. This packaging was chosen because it is sold from the nineties and is still being sold. Also, as observed in chapter "4,6 Benchmarking current mushroom packaging" multiple currently sold mushroom packaging have the same shape, or have a shape which is adapted from it. These packaging are only made from other materials and/ or colours. Interviews with packaging companies were performed to discover information that could not be found through literature research. In this chapter a summary of the main findings and is presented, in appendix I H, the elaborate set up, results and conclusion is presented.

To gather the information email contact was made with Ms C. Ouwehand, who is packaging specialist at the KIDV (Kennisinstituut Duurzaam Verpakken). Also, a telephonic interview was performed with Ms M. Verstappen, who is the commercial director at Verstappen Advanced Packaging. It was a structured interview via email, which can be read in Appendix I F. The telephonic interview was semi structured and in paraphrased in appendix I G.

Insights from interviews

The design of the blue mushroom container is a functional design. The packaging features protect the mushrooms and extend the shelf life. The packaging has structures on the side as on the bottom, which is to protect the mushrooms and to save material. The design of the mushroom packaging is made to make pre-packaged mushrooms an efficient product throughout its life cycle. According to the interviewees, the mushroom packaging is blue because the Dutch people prefer blue packaging, while in Germany a transparent packaging is preferred. The blue colour makes the mushrooms appear more white. An insight is, that there is no difference made between the quality of the mushrooms, because of margins in price. An interesting question could be if the mushrooms become more popular if there is a separation in quality. In figure 18, a visual summary of the results is presented.

Discussion of the found insights

In chapter "4.6 Benchmarking mushroom packaging" was found that mushroom packaging are sold in multiple colours. Comparing packaging from chapter "4.1 Packaging market" and chapter "4.6 Benchmarking mushroom packaging", the observation is that more packaging are transparent or have a different colour than blue. Only one packaging was found with a blue colour. This could mean that the preference for the colour blue has shifted to a transparent or different coloured packaging. The reason for a transparent packaging could be that the consumers like to see the food inside the packaging before buying it.

According to the interviewees the mushroom packaging is adapted to the life cycle of the mushroom, but if the packaging has not changed in shape over the years, it raises the question if it is still the most efficient way of packaging mushrooms. In a reusable packaging solution, pre-packaging could be a thing of the past. By pre-packaging mushrooms air is trapped inside the packaging, which is less efficient in transport.

The interviews were conducted about the blue mushroom packaging, which is an older packaging. Due to time limit only two interviews were performed about one packaging, to gather more insights interviews could have been conducted about other mushroom packaging.

Figure 18: Visual summary interview results about the blue mushroom container

4.8 Information on a mushroom packaging

Mushroom packaging have information either printed on the material or on a sticker that is stuck onto the packaging, unless it is a paper bag bought at the food market. A reusable packaging could be usable for multiple types of fruits and vegetables, which requires the information to be communicated in a different way than on the packaging itself. Below the information is summarized which needs to be on pre-packaged food products in the Netherlands (Nederlandse Voedsel- en Warenautoriteit, 2017).

If this information is not presented on the packaging the consumer is likely to start asking questions to employees from the supermarket. This information should be displayed in a different way, either at the supermarket or elsewhere. This is part of the sub research question "What does multiple-use packaging mean for the stakeholders involved in the fruit and/ or vegetable sector?" (Chapter "2. Approach"). To keep the packaging clean the currently used sticker needs to be replaced (Chapter "6.7 The disposal company"). In figure 19, a mushroom packaging is presented with the information presented on the packaging analysed. On the packaging it self, is the ID-resin code stamped. This code represents the used packaging material. A cup and fork sign is stamped in the packaging as well, which indicates that the packaging is designed for packaging food products(Curver Ltd., 2015).

Information that needs to be on a packaging;

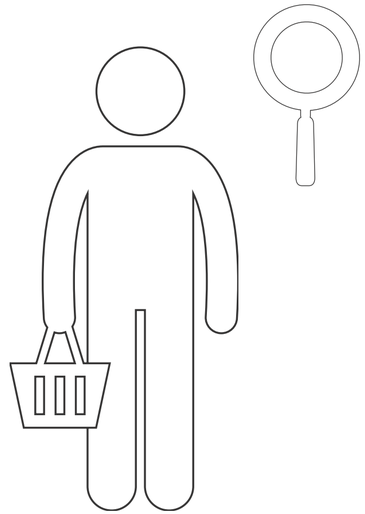
- Name food product
- List of ingredients
- Allergens
- Quantitative Ingredient Declaration (QUID)
- Net quantity
- Date of minimum durability / 'date
- Special storage condition / terms of use
- Name or business name and address of the operator
- Country of origin / place of provenance;
- Instructions
- Alcoholic strength by volume (beverages, > 1.2%)
- Nutrition declaration

Figure 19: Information displayed on mushroom packaging

4.9 Key findings packaging analysis

- Some of the current packaging have packaging features, which are fit for a reusable packaging but the current packaging are single use packaging. Greenhouse gasses can be saved if packaging only have the necessary features for the times of using that packaging.
- A way to keep materials together as the food inside the packaging is by having a lid which is part of the packaging, this makes the experience more simple and convenient for the consumer as well.
- Top seal packaging and a foil around a basket are currently pre-packaged products, but putting the seal or foil on the packaging in the supermarket, food spillage can be decreased or even prevented.
- Mushrooms are vulnerable to: Mechanical damage (pressures on the mushroom), temperature, humidity levels, carbon dioxide concentrations.
- With a reusable packaging solution the information normally presented on the packaging needs to be presented in another way.
- The preference of the consumer for a blue mushroom packaging is shifted to a transparent or other another coloured packaging
- Is pre-packaging still the most sufficient way of supplying and selling mushrooms, when looking at the complete supply chain? Transport of unpackaged fruits and vegetables can be more efficient.

5. Consumer research



The consumer is the stakeholder who buys the fruits and vegetables, consumes it, and throws away the packaging in the bin after the fruit and vegetables are taken out. The consumer buys the fruits and vegetables at a supermarket or at a food market, in this part of the report it is assumed that the consumer buys the fruits and vegetables at the supermarket.
Packaging and their functions and features are discussed in the previous chapter. The acquired information will be used for the interviews with the consumers. In this part of the report, a closer look at the consumer is taken to discover the consumer's point of view of the main research questions (RQ1 and RQ2). The consumer research chapter is divided into two parts. The first part discusses the involvement of the consumer in a more sustainable packaging solution. The second part discusses how to maintain or improve the consumer experience with a reusable packaging solution. Both parts are divided from the same interviews, this by combining the questions into one interview set-up. At the end of the consumer research, insights are concluded. The insights are used to create the criteria for the packaging solution and as inspiration for the packaging solution.

5.1 Introduction consumer involvement

This chapter discusses the research on how to lower the environmental impact of packaging from a consumer's point of view. The main research question (RQ1) is transformed into a sub-research question that is focussed on the consumer. The sub-research question is: "How to involve the consumer in a more sustainable packaging solution".

"Figure 20 illustrates the approach of this research. Literature research and interviews are performed.

Before starting the research, the predicted insights are stated (figure 20). These insights are predicted to be answered by the sub-questions. It is not excluded that more insights can be gathered from the research.

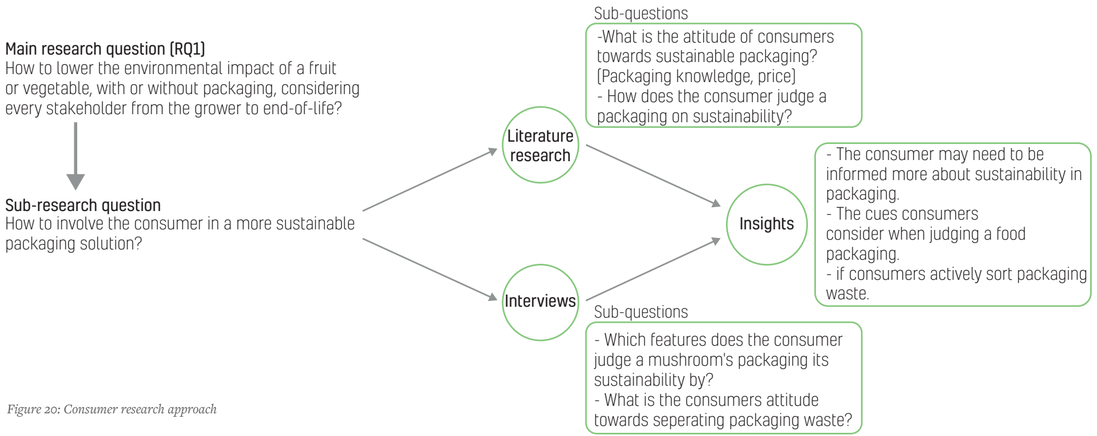


Figure 20: Consumer research approach

5.2 Consumer involvement Literature research

First, literature research is performed to gather information about the two sub-questions presented in figure 17. The insights acquired in the literature research are compared to the answers provided from the interviews, to discover whether Dutch consumers in general have an equal impression or whether there are significant differences.

The first sub-question: What is the attitude of consumers towards sustainable packaging?
Martinho (2015) states: "Interest in the development of sustainable packaging has increased in recent years, with several programs and initiatives having been investigated to improve the sustainability of packaging" (p.1). Lindh, Olsson, and Williams (2015) found that consumers state that they care about environmental impact of packaging but that they think it is a matter of material choice. This indicates a lack of knowledge about the environmental impacts concerning packaging. Consumer's understanding of a packaging its life cycle could create different results in packaging sustainability judgements. It was also found that consumers to large extent base their food packaging choice on convenience in handling of the product, the most named aspects were: easy to re-seal, easy to open, and packaging size (Lindh, Olsson, & Williams, 2015) . The research was done amongst Swedish consumers. In the interviews, the results of the Dutch consumers are compared to the findings from the research by Lindh, Olsson, & Williams. Steenis, Van Herpen, Van der Lans, Ligthart, and Van Trijp (2017) state: "However, getting consumers to choose sustainable packaged products is challenging" (p. 1). One of the factors that influence the attitude of consumers is price (Martinho, 2015). Research into the willingness of people to pay more for a product in a sustainable wrap, had the result that 19% of the consumers are willing to pay more and 63% would consider it (Martinho, 2015). Also, researched stated that people would prefer a recycled packaging over a non-recycled packaging, 67% would prefer a recycled packaging over a non-recycled packaging.

The second sub-questions is: "How does the consumer judge a packaging on sustainability".
The consumer may be actively thinking about sustainability when doing groceries but the cues of the packaging can be interpreted different per person. In research by Steenis, Van Herpen, Van der Lans, Ligthart, and Van Trijp (2017, pp. 295–296) is concluded: "that consumers sustainability perceptions are highly diversified, this could be because they perceive different aspects of sustainability and vary in how they believe packaging performs on such aspects". Steenis, Van Herpen, Van der Lans, Ligthart, & Van Trijp (2017, pp. 295–296) stated that: "...it is shown that these consumer perceptions do not align with life-cycle assessment; rather, consumers rely on their own lay beliefs and can be easily misled by salient cues that may not be very relevant for objective environmental impacts". As stated before consumers judge the environmental impact of a packaging on the used packaging material, but as well on the amount of packaging material used (Lindh, Olsson, & Williams, 2015). Although the consumer packaging choice is based on convenience, it can be considered as sustainable judgement that the consumer wants to extend the shelf life, by wanting an easy to re-seal packaging. But the questioned consumers did not connect shelf life to sustainability (Lindh, Olsson, & Williams, 2015).

To summarize, consumers are willing to be more sustainable in their choice for food packaging, but it depends on the price. Most of the consumers would consider to pay more for a sustainable packaging solution, and almost a part of the consumer are actually willing to pay more. Consumers rely their judgement on a packaging its sustainability mostly on packaging material and packaging amount, which indicates a lack of knowledge in packaging sustainability. A better understanding of sustainability of packaging could be achieved by understanding a packaging its life cycle. The next chapter compares the perception, acquired from the interviews, on the sustainability of packaging.

5.3 Consumer involvement interview research set-up

In this part of the report, the set-up of the interviews is explained. The set-up for the interviews is the same for the consumer involvement part as the reusable packaging experience part, apart from the interview questions

Method
Qualitative semi-structured interview. Questions are asked to the interviewees and depending on the answer more questions asked, to get argumentation for the given answer (Van Boeijen, Daalhuizen, Zijlstra, & Van der Schoor, 2014).

Procedure
Sixteen (n=16) interviews were performed from which one pilot. Four interviews took place in office places at the Bink in The Hague, and twelve interviews took place in Dordrecht at different households. The interviewees had ages between 24 and 67 years, from which seven persons were male and nine female. The total duration of the interviews was around 15 to 20 minutes.

Before starting the interviews, the interviewees were told that the interview is about packaging from the fruit and vegetable sector. The first part of the interview, were questions concerning all packaging of the fruit and vegetable sector. The second part of the interview, was about the blue mushroom container with the transparent lid. Before starting the second part of the interview, the blue mushroom container with transparent lid was presented and given to the interviewee. This was done to let the consumer feel and observe the packaging, while answering the questions. This was also done to get more elaborated answers to the questions. In figure 21, the sub-questions are connected to the interview questions that are made to answer that sub-questions.

Stimuli
To research the consumer its attitude towards separating waste, a packaging made from two materials was given to the consumers (figure 22). The attitude towards separating waste shows whether the consumers put the effort into acting sustainable after the packaging is used. The degree of separation of that packaging was asked, in which the optimal situation is if people throw away the cardboard tray in the paper bin and the plastic bag in the plastic bag for plastic waste. By giving the interviewee the real product, he or she does not have to imagine or guess the properties of the packaging from an image.

The other stimuli was the blue mushroom container with the transparent lid (Figure 23). To prevent influencing the participants, the mushroom packaging was hidden until the second part of the interview that contained questions about the mushroom packaging. The mushrooms were not mentioned before the second part of the interview as well, for the same reason.

Figure 22: Packaging shown in interview as stimuli.

- On which features does the consumer judge a mushroom packaging its sustainability?
  - Are you actively thinking of sustainability when doing groceries at the supermarket?
  - Could you explain why certain fresh fruits and vegetables are packaged?
  - What do you think of the appearance of this packaging? (Shape, colour, material feeling),(about mushroom packaging).
  - Do you think it is a sustainable packaging? And why? (About mushroom packaging)
- What is the consumers attitude towards separating packaging waste?
  - How do you separate this packaging, when disposing of it? (About figure 18)

Figure 21: Sub-question connected to interview questions.

5.4 Interview results consumer involvement

Figure 23: Blue mushroom container with transparent lid, used as stimuli in the second part of the interview

Set-up analyses interviews
The interviews are analysed via summarizing and paraphrasing of the recorded interviews. The written interviews are presented in appendix II A - P. From the written interviews a summary is written with the answers of the interviewees stated per question, this to create an overview per question (appendix III A).

From that overview is analysed what results can be used to give answer to the sub-questions. Per interview is looked at words and lines to discover insights that may be named by the interviewees.

The amount of interviewees are not enough to make hard and significant proven conclusions, but collected data provides valuable insights that will be treated as an indicator of Dutch consumer behaviour.

This chapter explains the results of the interviews. The results are structured per sub-question as structured in chapter “5.3 Consumer involvement interview set-up”. After the results conclusions are stated and the research discussed. The results per interview question are presented in appendix III A.

Results
Most of the consumers claim to be thinking of sustainability when doing grocery shopping, but actually, the fruits and vegetables itself were found more important. It is looked if the fruits or vegetables are fresh and of good quality. Although most of the interviewees prefer unpackaged fruits and vegetables, one of the reason was to save plastics.

Most of the interviewees named that packaging extends the shelf life of fruits and vegetables, but none of the interviewees named food spillage or sustainability with a longer shelf life. One of the interviewees connected shelf life and packaging with convenience in transport, that interviewee also connected it with efficiency in transport. Other named functions in the interviews were protection, hygiene and predetermined portions. The last function was connected to more sales, not to food spillage or sustainability.

The interviewees were asked what they think about the appearance of the blue mushroom container with the transparent lid. This was done, to let the interviewees rethink al the features of the packaging. None of the features was connected with sustainability. This could also be because they were not asked to connect it to sustainability.

Literature research showed that consumers judge the sustainability of packaging on used material and material volume. According to 13 of the 16 interviews, the packaging is unsustainable. The consumers judged it all on ’’ material”, the named reason was, “it is made from plastic, which is not sustainable”. The interviewees used colour as sustainability judgement as well. According to most of the interviewees, coloured plastic is less sustainable than transparent plastics. They also perceived cardboard material as more sustainable. The volume of material was named as criteria on sustainability in the literature research, this judgment criterion was used by multiple interviewees as well. The volume of material was always named in combination with the kind of material. One of the named answers about the volume of material was, the thin wall thickness of the packaging.

The last interview question showed that six of the consumers separated packaging waste as intended (cardboard tray in the paper bin, and plastic in the plastic bag for plastic waste). Four of the consumers would not separate the packaging, and six interviewees would separate plastics and cardboard, but throws the plastic in the residual waste bin. This data shows that most of the interviewees are willing to separate waste, but not all the interviewees seperate and dispose the waste the in the intended way.

Conclusion

To conclude, the consumer is becoming aware of sustainability. When it comes to buying fruit and vegetables, convenience and quality of the fruits and vegetables are more important sustainability. Also, only around 20 per cent of the consumers are actually willing to pay more for a sustainable food product. No, significant data about separating waste by consumers was deducted, but from small qualitative research is deducted that most consumers are willing to separate packaging waste.

According to literature research, consumers rely on material and material volume to judge the sustainability of packaging, which was substantiated by interview results. Also discovered is that consumers look at the colour of plastics in sustainability judgements. This because according to the consumers coloured plastic has a worse impact on the environment than transparent packaging. The lack of knowledge about sustainability concerning packaging was supported by the interviews.

If the consumers have more knowledge about the life cycle of packaging and/ or fruits and vegetables, they may judge a product on more features than just the material. A way to reach the consumer with information that activates them, to learn and to change their buying behaviour, is to be designed.

Discussion

The research performed into how to involve the consumer in sustainable packaging, was done through literature research as semi-structured interviews. To discover more about consumer behaviour concerning packaging, more literature research could have been performed. Now only a few research results from papers are used, but to verify more, multiple studies could have been searched to substantiate the data.

The amount of interviews performed, is not enough to get significant data to make hard conclusions, but the insights retrieved from the interviews will be used as indicator of Dutch consumers. If the data cannot be used it is noted in the results or in the discussion.

The interview question about if people actively sort packaging waste and how they sort it, could have been tested through quantitative research. However, this was discovered late and due to limited time in this project, it was not redone. The data retrieved from this question now is based on 16 interviewees.

The consumers were evaluated, whether they connect sustainability to its features, to discover their knowledge of packaging sustainability. With the last question the interviewees were asked directly for a sustainable judgement of the mushroom packaging. By putting the consumer on the spot they are forced to name reasons why they think it is sustainable or not, it could be that the interviewees did not come up with all the sustainable knowledge they posses at once. This influences the results of the test and judgement by me on their knowledge about sustainability.

5.5 Key findings

- Consumers relay on material and material volume to make a judgement on a packaging its sustainability
- Colour is taken into consideration when determining a packaging its sustainability.
- The consumer perceives cardboard as a more sustainable material than plastic.
- The consumer looks at convenience of the packaging, and quality of the fruit or vegetable when buying fruits and vegetables.
- Easy of resealing, easy to open, and packaging size are packaging buying considerations of consumers.
- To involve the consumer in sustainable behaviour concerning packaging, they should be informed more about sustainability aspects of packaging.

5.6 Introduction reusable packaging experience research

In chapter "4. Benchmarking current Fruit & Vegetables packaging", multiple fruits and vegetable packaging are collected and analysed on functions, features, materials, and feeling. In this chapter, the consumers thoughts about multiple-use fruit and vegetable packaging are researched by asking for packaging experiences. The second main research question(RQ2), is researched by literature research and interviews (figure 24).

The sub-question from chapter "2. Approach": "What does multiple-use packaging mean for the stakeholders involved in the fruit and/ or vegetable sector?". This is analysed by researching the thresholds consumers have towards reusing packaging and what the perceptions of consumers are towards reusable packaging.

In figure 24, the predicted insights from this research are presented. This does not exclude other possible insights that may be retrieved from this research.

As mentioned in "5. Consumer research" and chapter "5.3 Consumer involvement interview research set-up", to research the reusable packaging experience the same interviews were used and so the same set-up.

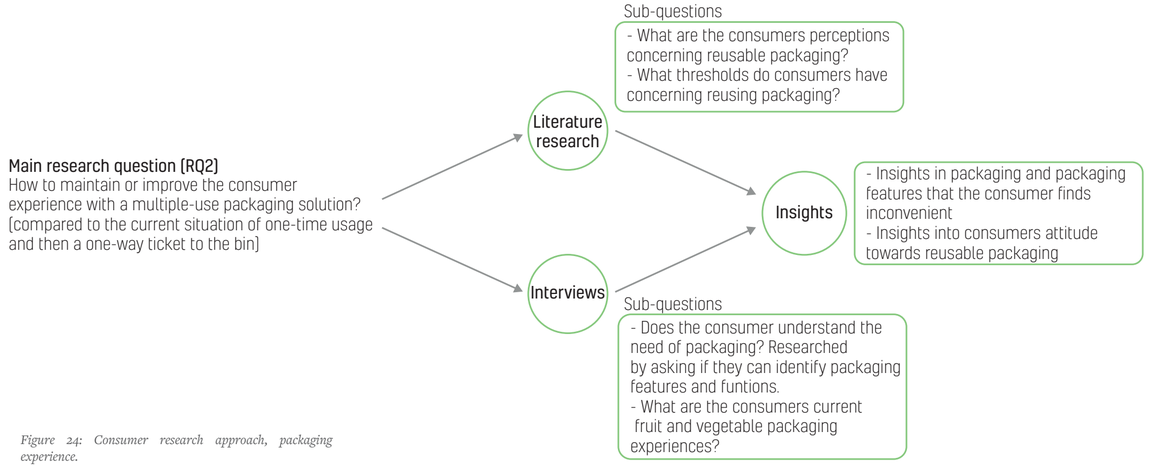


Figure 24: Consumer research approach, packaging experience.

5.7 Reusable packaging perception literature research

First, literature research is performed to gather information about the two sub-questions presented in figure 24. The insights from the literature research are analysed and key finding made. This chapter researches the consumer perceptions and thresholds concerning reusable packaging.

The first sub-question: "What are the consumers perceptions concerning reusable packaging?".
The consumers interest in sustainability has risen (Martinho, 2015). It was found that the intentions of consumers are strongly depended on situations that facilitate reuse, if situations facilitate reuse of packaging the consumer will perceive it as less inconvenient (Ertz, Huang, Jo, Karakas, & Sarigöllü, 2017). Then, the consumer will feel more motivated. According to Ertz, Huang, Jo, Karakas, and Sarigöllü (2017), the western consumer is more influenced by context factors. A way to influence the consumer behaviour in favour of reusable packaging, is by offering a different price for consumers who use a reusable packaging (Ertz, Huang, Jo, Karakas, & Sarigöllü, 2017). Lofthouse and Bhamra (2006) state, that the consumers identify the following environmental benefits of refillable packaging: the use of less material, generation of less waste, less impact through manufacturing, and a reduction of containers going into shops.

The second sub-question: "What thresholds do consumers have concerning reusing packaging?".
For consumers to actively use reusable packaging certain threshold need to be over-won. In research by Lofthouse, and Bhamra (2006), the following problems concerning refillable products were discovered:

- No room for amount of products that need to be stored.
- Fear of technology
- Skill in filling of the product
- Availability
- Social behaviour

The threshold of skill in filling of the product was found to be connected to filling of food products. Not all problems may be applicable to reusable mushroom packaging, for example availability, this is not a problem which is changing at a supermarket or food market if a packaging becomes reusable. These threshold values are not specific to a fruit or vegetable reusable packaging, but are taken into consideration in designing of the packaging solution

Summarizing the literature research, the consumers are becoming more sustainable aware, but acting more sustainable by buying and using reusable packaging depends on lowering the involved inconveniences. No room for storage, and skill in filling of the product are threshold values that can directly be connected to a reusable packaging. A way to lower the threshold values is by adapting the buying environment to a reusable packaging environment, which was also mentioned in chapter"3,5 Economical aspect". It was stated that the current supermarkets are not adapted or fit for reusable packaging.

5.8 Interview set-up reusable packaging experience

As mentioned in chapter "5.3 Consumer involvement interview research set-up", the interview questions for both the consumer involvement as the reusable packaging experience part were combined in one interview set-up. In this chapter, the interview questions are stated connected to the sub-questions of the reusable packaging experience part. The elaborate set-up of the interviews can be read in chapter "5.3 Consumer involvement interview research set-up", except for the used interview questions in this part, which are stated in figure 25.

- Does the consumer understand the need of packaging? (Researched by asking if they can identify packaging features and functions)
  - Could you explain why certain fresh fruits and vegetables are packaged?
- What are the consumers current fruit and vegetable packaging experiences? (Questions about the mushroom packaging)
  - Which packaging from the fresh fruit and vegetables sector is most inconvenient for you? And why?
  - What do you think of the appearance of this packaging? (Shape, colour, material feeling)
  - Have you ever had a bad experience with the mushroom packaging?
  - What do you do with the packaging, if you only use a number of mushrooms and want to store the remaining mushrooms?
  - When doing groceries, are you thinking of where to lay the mushrooms, on top or at the bottom of the cart? And why?
  - Can you tell me the functions of the lid of the blue mushroom packaging?
  - Could you tell me how you use this packaging and the mushrooms, from taking it out of the fridge till throwing it away?

Figure 25: Sub-question connected to interview questions.

5.9 Interview results packaging experiences

This chapter discusses the results of the interviews. The results are structured per sub-question as structured in chapter “5.3 Consumer involvement interview research set-up”. The results per interview question are presented in appendix III A.

Results

The interviewees named multiple reasons for packaging fruits and vegetables. The three most named reasons were: hygiene, extending shelf life, and a predetermined amount of fruits or vegetables. The last function was connected to more food products being bought, but non of the reasons were connected to sustainability by the interviewees. Other reasons that were named less were: protection of the fruit and/ or vegetables, convenience during transport to the supermarket from the grower as transport to the homes of the consumer, and preventing consumers from touching the fruit and vegetables inside the supermarket. Some of the reasons that were named can be connected to sustainability, but this was not done. It can not be said if the interviewees did connect the functions to sustainability by themselves.

An experience with packaging that multiple interviewees encountered, is that a fruit or vegetable cannot be removed from the packaging without damaging it. This is not convenient when wanting to reuse a packaging.
Another inconvenient experience, is difficulty in opening of the packaging. In chapter “5,2 Consumer involvement literature research” it was noted that consumers judge a packaging on convenience, and an important factor is convenience in opening of a packaging, the answers of the interviewees substantiate this. Experiences concerning baskets were unintentional opening of the lid during transport, tearing of the basket, and fruits and vegetables getting bruised by mechanical damage during transport.

The opinions about the appearance of the blue mushroom container deviated. Multiple interviewees said; they perceive a connection between a blue plastic basket and white mushrooms. It was asked, if the interviewees have a favour for the blue colour, but the data for this deviated too much to make a clear recommendation. Multiple interviewees liked the transparent lid, because it enables them to see the quality of the mushrooms.

The most named negative experience with the blue mushroom container, was the lid coming of. This creates problems with storing of the mushrooms. When the packaging is opened, it cannot be resealed, according to most of the interviewees. The lid of the blue mushroom container causes inconveniences.

For context, was asked how the interviewees store mushrooms after a few of mushrooms are taken out. Most of the interviewees store the mushrooms inside the packaging with the lid in the upright position. Two interviewees, knew that the lid can be put in the container upside down, when storing mushrooms.
As analysed in chapter “4,6 Information on a mushroom packaging”, there is no information on the mushroom packaging about the features of the packaging. From the interview results, was derived that to little information is presented on the blue mushroom packaging.

Most of interviewees pay attention to where they place the mushrooms, they consider what can be stacked on top of it. The confidence the packaging abilities to put all kinds of groceries on top of the packaging is low.

Multiple functions from the lid were identified, but it was named multiple times that more information about the usage of the packaging should be presented on the lid. The blue mushroom packaging was designed in the nineties, but still most of the consumers can not identify all of the packaging features. This while most of the interviewees buy mushrooms at least once a week.

From the interviews was deducted that some consumers use the blue mushroom container as temporarily waste bin during cooking.

Conclusion

To make consumers buy and use reusable packaging, the inconveniences of storage room for bulk of reusable packaging and skill in filling of the packaging need to be considered. Threshold values can be lowered by adapting the context, so for example adapting the supermarket to a reusable packaging grocery shopping.

The consumers have knowledge about packaging functions, and the assumption is made that the consumers do understand the need of packaging. The interviewees had multiple inconvenient experiences with fruit and vegetable packaging, from which opening and resealing of a packaging were identified the most times. These are two features, on which a consumer makes its judgements on whether to buy a food product.

The blue mushroom container, has given insight in the importance of presenting information about packaging features. The information of packaging features could be presented with the use of use-cues, instead of using text. Most of the interviewees do pay attention on where to place mushrooms when doing groceries, attention is paid to the weight stacked on top of it.

Most of the interviewees storage mushrooms inside the packaging, some also use it as temporarily storage bin during cooking.

Discussion

In the previous chapter, research is performed into consumer experiences with packaging and the consumers attitude towards reusable packaging. Information concerning consumer behaviour round reusable food packaging, was difficult to find. After searching for research papers, two were found from which one covered more than just reusable food packaging. From the papers, relevant information was retrieved, but if more time was available more extensive research into consumer behaviour concerning reusable packaging could have been performed. More sources would have created a more solid research and conclusions.

The interview questions were taken from the blue mushroom container, which as established earlier, is a packaging from which multiple packaging are derived. To gather more insights, questions about more packaging should have been asked. Also, the interview questions were based more on retrieving information concerning current single-use packaging, while the objective in this part of the consumer research was to retrieve consumer insights into packaging experiences with reusable packaging. If the identified inconveniences with reusable packaging are the same as single-use packaging needs to be researched. This means, no objective judgment on reusable packaging experience from the interviews can be deducted. However, in this report, the retrieved insights are used as a reference to design the reusable packaging solution.

5.10 Key findings

- Another way of using the blue mushroom basket is as temporarily waste bin.
- Consumers lack knowledge to discover all packaging features if no use cues, or text is available. The consumer should be informed more about the packaging itself.
- Most inconveniences come from opening and resealing packaging.
- Reusable packaging has threshold values for consumers that can be over-won by designing the context next to the packaging.
- Consumer threshold values of reusable food products are; no room for storage of the products and skill in filling of the product.
- Mushroom are a delicate vegetable, the consumer knows this, and pays attention to where to place the packaging during grocery shopping. This to remain the quality of the mushrooms.

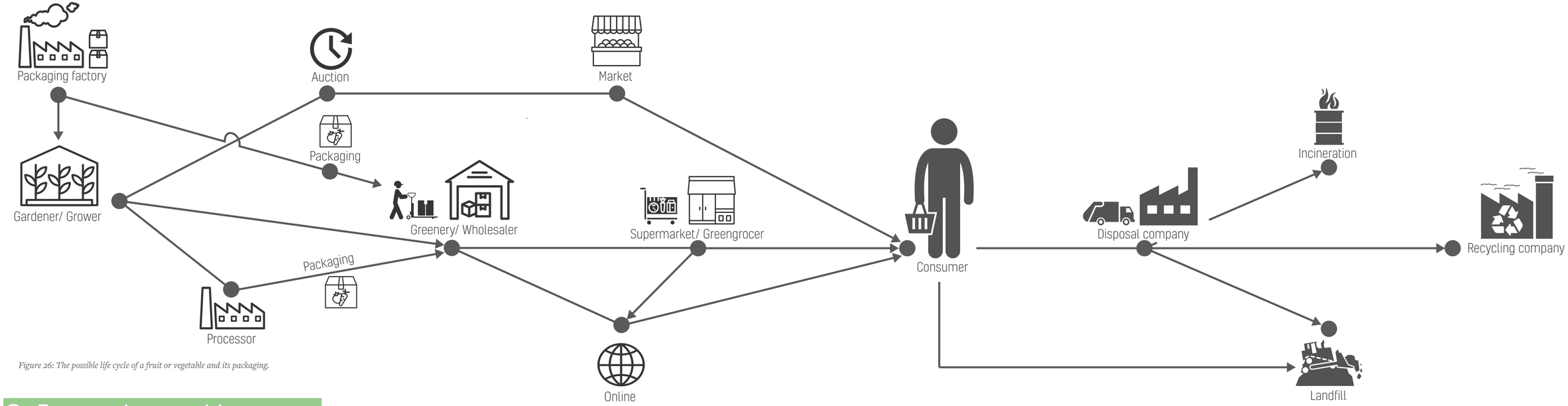


Figure 26: The possible life cycle of a fruit or vegetable and its packaging.

6. Fruit and vegetable journey

The stakeholders that are in a fruit and vegetable its life cycle are analysed in this phase of the project. Figure 26 illustrates an overview of a fruit and/ or vegetable its life cycle and its packaging. It is illustrated as introduction into the fruit and vegetable sector. In this project, the focus is the mushroom, but in this part of the project not all the data is specific to the mushroom. This to gather insights that can be useful for multiple fruits and vegetables life cycles. The fruit and vegetable journey is analysed per stakeholder, in order to get answers to the first main research question (RQ1): How to lower the environmental impact of a fruit or vegetable, with or without packaging, considering every stakeholder from the grower to end-of-life?. At the end of this phase, an overview is presented with the possible improvements that could be taken into consideration in the design of the packaging solution. A reusable packaging solution is the objective in this project, which is why the following sub-question is derived from the main research question(RQ1): What does multiple-use packaging mean for the stakeholders involved in the fruit and/ or vegetable sector?. This is researched by discovering current fruit and vegetable packaging demands from the stakeholders. This is established by email contact and telephonic interviews, with the stakeholders involved in the fruit and vegetable sector. The end-of-life methods, are analysed to gather insights in the possible possibilities of those processes. The relevance of these processes in this project depend on the life time of the reusable packaging solution.

6.1 Analysed stakeholders

In the introduction, the stakeholders in the life cycle of a fruit or vegetable and its packaging are illustrated. From the stakeholders in figure 26, a selection was made. The stakeholders that are responsible for the packaging design and who receive most feedback from other stakeholders are further analysed. In this part of the project the consumer is analysed on potential environmental impact in processes concerning packaging. The supermarket was selected over online and the food market, because at the supermarket multiple experiences come together; pre-packaged fruit and vegetables, unpackaged fruits and vegetables, consumer grocery shopping experiences, and consumer feedback. Also, was mentioned in chapter "3,5 economical aspect" that the supermarkets are not adapted to reusable packaging, which is an extra reason to prefer the supermarket over the food market in this project. In figure 27, the flow of a fruit or vegetable and its packaging is shown, with the stakeholders that are researched in this phase of the report.

In the next chapters, the following subjects are researched per stakeholder:

- Role of the stakeholders in a fruit or vegetable its life cycle.
- Environmental contribution. (To gather insights about possible improvements in the stakeholder chain)
- Demands of a fruit or vegetable packaging (To discover insights and demands for a reusable packaging solution in the stakeholder chain. This partly answers the sub-question derived from RQ2, stated on the previous page).

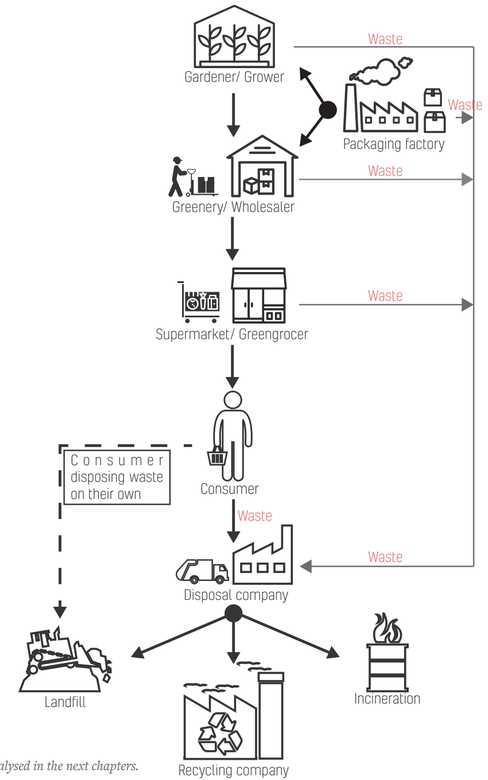


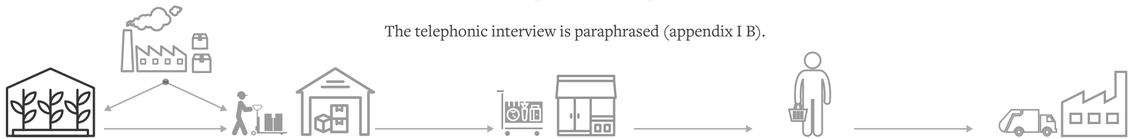
Figure 27: Stakeholders analysed in the next chapters.

6.2 The grower

At the beginning of the fruit and vegetable its life cycle is the grower. Mushrooms are grown in a "cultivation cell" (Figure 28),(Van Asseldonk Champignons,n.d.). The mushrooms are grown at this stakeholder and either packaged in a crate or in one of the packaging presented in chapter "4.6 Benchmarking mushroom packaging". Figure 29 shows a pre-packaged mushroom packaging inside a crate. From the grower, the packaging is transported to the greenery/ wholesaler or directly to the supermarket.

Environmental impacts

Ntinas, Neumair, Tsadilas, & Meyer (2017) state: "the horticultural section consumes significant amounts of energy for agricultural machinery operation, irrigation, use of chemicals, micro climate control (heating and cooling), transport and refrigerated storage". For the reusable packaging solution efficiency could be made higher by making transport more efficient and by saving energy. That is if the mushrooms are not pre-packaged in plastic containers at the grower.



Interview

A telephonic interview was taken with the Managing partner product and Market Innovation Mr. J. van Mill from Greenco. This company grows, packages, and sells small tomatoes.

The main objective of the interview, was to discover insights and demands for a reusable packaging solution in the stakeholder chain.

A 20 minute semi-structured qualitative interview was taken. The interview questions are stated in appendix I B.

Interview results

According to Mr. J. van Mill, the packaging demands they have for a packaging are:

- The consumer needs to be able to see all fruits and vegetables, which means the packaging needs to be transparent.
- The packaging needs to be 100 per cent recyclable.
- The packaging needs to convenient in picking up by the consumer.
- The packaging needs to keep the vegetables contained.
- Convenient to be placed and transported in a crate.

The telephonic interview is paraphrased (appendix I B).

Figure 28: White mushroom cultivation cel,retrieved from Angelucci (2016).

Figure 29: White mushroom pre-packaged in a blue crate in rows of three.

Interview conclusion

The demands are categorised as convenience and environmental responsibility. Convenience at the consumer and at the grower are the most important to the grower, according to the packaging demands.

6.3 The packaging industry

The packaging industry is the stakeholders who designs, produces, and sells the packaging to either a grower or greenery/ wholesaler. Most mushroom packaging have either information printed on the packaging or a sticker onto it, this can be seen chapter “4.6 Benchmarking mushroom packaging”. The packaging industry, produces a packaging which is either specific for a retail shop or can be personalised to a retail shop by a sticker or printed information on the packaging.

Environmental impacts
Research into life cycle stages of a mushroom tray, was found that raw material contributes for 45 per cent of the greenhouse gas emissions (Dormer, Finn, Ward, & Cullen, 2013). Manufacturing accounted for 38 per cent of the emitted greenhouse gasses (Dormer, Finn, Ward, & Cullen, 2013). In research was found that the carbon footprint it most depended on material choice and weight of the crate (Dormer et al., 2013). Logistics accounted for 3 per cent of the total greenhouse gas emissions. In short, the greatest reductions in mushroom packaging can be made in the raw material and manufacturing life cycle phases.

Interview
Email contact was established with the Sales director Mr. M. Mill from Oerlemans Packaging BV. This company specialises in flexible packaging.

The main objective of the email contact, was to discover insights and demands for a reusable packaging solution in the stakeholder chain.

This was done by asking questions about the company it self, and by asking what demands they have of a fruit or vegetable packaging.

Interview results
The results of the interview are the demands for a packaging. According to Mr. M. Mill a fruit and/ or vegetable packaging must meet the following demands:

- The packaging must be convenient for all stakeholders in the fruit and/ or vegetable its life cycle.
- The packaging must protect the fruits and vegetables inside.
- The packaging must comply to all the food safety regulations.
- Sustainability: The packaging must be 100 per cent recyclable after usage.
-

The email contact is presented in appendix I C.

Interview conclusion
Multiple demands were named with different functions. Four demands were given. From the interview can be deducted that the packaging needs to be protective not only for the consumer, but for all stakeholders involved in the packaging its life cycle.

6.4 The greenery

The greenery can also be named a wholesaler of fruits and vegetables. The role of the greenery is delivering fresh fruits and vegetables to supermarkets, wholesalers, local stores and processors daily (The greenery, n.d.-a). In figure 30, an example of the inside of a greenery or wholesaler is presented. The greenery receives fruits and vegetables from the growers, and sometimes the greenery makes sure the products are transported from the grower directly to the supermarkets or other stores (The greenery, n.d.-a). A greenery, also creates their own packaging (The Greenery, n.d.-b).

Environmental impacts
The greenery mainly arranges transport, which is why it is assumed that transport is the greatest environmental contributor of a greenery. A tray filled with mushrooms, accounts for 22 per cent of the total carbon footprint (Dormer et al, 2013). Reducing of the environmental impact of the greenery can be done by making transport more efficient and by lowering the weight of the tray.

Interview
Email contact was established with a Mr. A. Koot from the company , The Greenery. The Greenery specialises in delivering fresh fruits and vegetables to the costumers.

The main objective of the email contact was to discover insights and demands for a reusable packaging solution in the stakeholder chain.

This was done by asking questions about the company it self, and by asking what demands they have of a fruit or vegetable packaging.

Interview results
According to The Greenery a fruit and/ or vegetable packaging must meet the following demands:

- Sufficient protection of the fruits and vegetables.
- Extending the shelf life of fruits and vegetables.
- The packaging must have presentational possibilities.
- The packaging must be convenient for the consumer.

The email contact is presented in appendix I D.

Figure 30: Image of the inside of a fruit and vegetable wholesaler, retrieved from

Interview conclusion
To conclude the greenery, named demands concerning the quality of the fruit or vegetable and concerning presentation. The sustainability of the packaging it self was not named.

6.5 The supermarket

The supermarket sells all kinds of food products, varying from fresh food products to preserved food products (Figure 31). The supermarket gets the fruits and vegetables from either a greenery, wholesaler from the supermarket itself, or directly from the grower. If the fruits and vegetables are pre-packaged, the information is either printed on the packaging or a sticker with information is put onto it. Unpackaged fruits and vegetables are packaged at the supermarket in a plastic bag by the consumer, after which it is weighted and a sticker with barcode put onto the plastic bag. The supermarket collects Polyethylene terephthalate bottles and glass beer bottles in a crate, for which the consumer gets a part of the money in return, after returning of the packaging. The pre-packaged mushroom in the supermarket are either presented in the refrigerator or loose somewhere in the fruit and vegetable section, as presented in figure 32.

Environmental impacts
The supermarket keeps the food fresh before it is bought by the consumer. This means for some products that refrigerators are used, which use electricity. The supermarket has food waste from products that are damaged before reaching the supermarket, but also from damaging at the supermarket. Some products may also pass their expiration date at the supermarket. The fruit and vegetables are transported to the supermarket, and the consumers go back and forward to the supermarket. Reduction can be made by replacing the single use plastic packaging for a reusable solution, and by making transport more efficient for the consumer as the greenery.

Interview
An telephonic interview was performed with the owner of Plus supermarkets Dordrecht, named Mr. P. 't Lam.

The main objective of the interview was to discover insights and demands for a reusable packaging solution in the stakeholder chain.

A 15 minute semi-structured qualitative interview was performed. To get answers to the main objective of this interview multiple questions were asked which are presented in appendix I A.

Figure 31: The fresh fruit and vegetable section in a supermarket, retrieved from Van Looveren (2016).

Figure 32: Mushrooms at a supermarket presented in the supermarket outside the refrigerator.

6.6 The consumer

Interview results
No packaging demands were deducted from the interview, because the supermarket itself has no say in the packaging. In the interview was discussed that the consumers are becoming more sustainable aware, and are starting to question the amounts of packaging used for fresh fruits and vegetables. A development is food products aimed at single people's households. Consumers also want healthy food. Food that is healthy and quickly prepared.

The telephonic interview is paraphrased (appendix I A).

Conclusion
Consumers are becoming more sustainable aware, but the supermarkets are still selling single use packaging and are not adapted yet to a more sustainable way of selling fruits and vegetables.

The consumer is the person who buys the fruits and vegetables. This chapter discusses the role of the consumer in the fruits and vegetable it life cycle, and the consumer its contribution to the environmental impact.

The consumer has multiple channels to buy mushrooms. The consumer buy mushrooms at the supermarket, at a food market or online as illustrated in figure 26. Figures 33 and 34, give an image of the consumer at the food market and supermarket. After the consumer has used the contents of the packaging, it is most of the time disposed of. The packaging needs to be sorted on material by the consumer, and then placed in the bin. Packaging that are thrown away on the streets, end up in the residual waste bin, if picked up(Milieu Centraal, n.d.). Waste in the residual waste bin is not probably not recycled (Milieu Centraal, n.d.). The harms of packaging waste are described in chapter "3. Background packaging waste".

Environmental impacts
According to chapter "3.4 Food spillage" the greenhouse gas emissions are mostly caused by cooking of the vegetables, which is not taken into account in this project. Other impacts by the consumer are transport, food spillage, and impacts caused by bad sorting of waste and street litter.

Figure 33: The consumer at the food market.

Figure 34: The consumer at the fruit and vegetable section in the supermarket, retrieved from BioForum Vlaanderen (n.d.).

6.7 The disposal company

The disposal company, is the stakeholder who collects the household waste and company waste. Disposal companies either recycle the waste, incinerate it or dump it as landfill. When the packaging is recycled, it is currently recycled by mechanical recycling. In 2015, PlasticsEurope states: ‘‘Recycling is the preferred option for plastics waste. However, when recycling is no longer the most sustainable option, energy recovery is the alternative. Both options complement each other and help realise the full potential of plastics waste.’’. Mechanical recycling of plastics is the conversion of plastic waste into secondary resources or products, with this conversion the chemical structure of the material does not changes significant (PlasticsEurope, n.d.). Another kind of recycling, which is still in development is chemical recycling. In chemical recycling, depolymerization of the polymers of the waste take place, in which the monomers are purified from contaminations (Grigore, 2017). In appendix III B, the two recycling processes are explained in detail. In appendix III C, the following end of life processes are explained: incineration, landfill and recycling.

Environmental impacts

Despite the more advanced waste sorting and ways of recycling, it is still important that waste is sorted upfront at the consumer as well as possible. The more sorting processes the waste has to go through, the more energy is used and more greenhouse gasses are emitted. The disposal company has to transport the packaging waste, in chapter ”4,3 Packaging materials” the insight was deducted that basket packaging have trapped air inside. When a packaging is not made small by the consumer it is less efficient in transport, the disposal company is then partly transporting air.

Interview

To get insights into what the current possibilities in recycling of waste are and what needs to be taken into consideration when designing the packaging solution, a telephonic interview was taken with the consultancy manager from the company Renewi, named Mrs. K. Meulenbroeks.

A 15 minute semi-structured qualitative interview was conducted. To gather insights four questions were asked to the interviewee.

Interview results

It was explained, that laminated packaging of multiple materials are difficult to separate in the sorting process and are presumably incinerated. The same for cardboard packaging with plastic around them, if these are not sorted at the consumer, it is more likely that the packaging are incinerated. A price tag on a packaging can influence the purity of a packaging, and so the recycling possibilities. To have a greater recycling rate, it is best if the packaging is made of one material, or has clear instructions for the consumer on how to sort the packaging.

Coloured plastic can not be recycled into white plastic, for example, red plastics cannot be recycled into white plastic only into red or black plastic. Transparent foils can be turned into transparent foils again, if it has a purity of 98 per cent. White paper can be turned into white paper again, but not if the paper has a lot of ink on it, as for example, a magazine.

Most plastics cannot be recycled into a food packaging, because all plastics are collected together. This means the material can get contaminated by other waste products. Polyethylene Terephthalate bottles are the only products that have its own waste stream, and therefore can be recycled into a food packaging by mechanical recycling.

In appendix I E, the telephonic interview is paraphrased.

Conclusion

To have a greater recycling rate the consumer has to sort waste better. To support the consumer, packaging should have more clear instructions on how to sort it, or the packaging should be made of one material. A separate waste stream for food packaging, enables the recycling of a food packaging into a food packaging again. The quality of the packaging materials can be retained by getting rid of price tags.

6.8 Overview findings per stakeholder

In this chapter, an overview is given of processes that take place at the stakeholders and challenges that could be improved. By improving the challenges the environmental impact of packaging are lowered, or packaging experiences improved.

The grower

Processes

- Grow of fruits and vegetables
- Packaging mushrooms in crates or pre-packaged in plastic container.
- Transport from grower to the greenery or supermarket

Challenges

- Keeping the mushrooms fresh.
- Transport efficiency in weight and volumes of the mushrooms packaged.
- Food safety and Hygiene

The supermarket

Processes

- Adapted to single use packaging
- Pre-packaged as unpackaged fruits and vegetables
- Transport to the consumers (home delivery).
- Information communicated on stickers.
- Unpackaged fruits and vegetables packaged in plastic bag by the consumer itself.
- Collecting of PET bottles with refund system.

Challenges

- Another way of communicating information than on a packaging.
- Adapting of single use to reuse.
- Food safety and hygiene
- Making transport to the supermarket more efficient.
- Keeping the mushrooms fresh (limited shelf life)

The packaging industry

Processes

- Designing and producing packaging.
- Transport from packaging industry to the grower or the greenery

Challenges

- Designing a packaging that is efficient for multiple stakeholders.
- Efficient packaging in transport, a least air transported as possible.

The consumer

Processes

- Buys fruits and vegetables at the supermarket, food market or online.
- Transport from home to the supermarket
- The consumer does not always sort packaging waste as intended.

Challenges

- Informing the consumer about packaging sustainability.
- Making the consumer sort their packaging waste better.
- Making the consumer overcome reusable packaging thresholds.

The greenery/ wholesaler

Processes

- Transport to and from the greenery to supermarkets, wholesalers, local stores and processors
- Sorting of fruits and vegetables and planning

Challenges

- Efficient stacking of fruits and vegetables
- Transport efficiency in weight and volumes of the mushrooms packaged.
- Keep the fruit and vegetables fresh during storage and transport.
- Food safety and hygiene

The disposal company

Processes

- Mechanical recycling, and chemical recycling (in development).
- Collecting waste at the consumer
- Recycling, incineration, and landfill.
- Sorting of waste.

Challenges

- Sorting of packaging waste.
- Efficiency in transport (Transport of air, making a packaging that can decrease in size)
- Influencing other stakeholders to make packaging of one material, and to lose stickers on packaging.
- A separate food packaging waste stream.

6.9 Conclusion and discussion fruit and vegetable journey

Conclusion

Every stakeholder has certain demands for packaging. From the interviews, it was deducted that demands concerning the convenience of a packaging and environmental responsibility, were most valued by the grower. The weight of the packaging influences multiple features in the life cycle of a product. More weight influences the carbon footprint of transport throughout the stakeholder chain. It was found that stakeholders were fruit and vegetables are stored, demands concerning shelf life were most valued. Another important demand was to make sure there is room for presentational purposes on the packaging. The consumer is becoming more aware of all the plastic packaging used in the fresh fruit and vegetable sector. The supermarket owner named that consumers nowadays want more healthy and quickly prepared food. Although the consumer wants to be more sustainable, they can improve their behavior by better sorting of waste. To make the recycling rate higher, packaging should be made from one material, also to make sorting easier for the consumer. The greenery may want space on the packaging for more information, but to prevent harming the purity of the material stickers should be replaced by another solution.

Discussion

To discover what multiple-use packaging means for the stakeholders, the demands of the stakeholders of fruit and/or vegetable were asked. Upfront, more in-depth packaging demands were expected, the given demands were demands that were logical to each of the stakeholders, but not all specific and or unique for that stakeholder. Although, insights were retrieved from the named demands. The next time, it is better to ask directly to their vision of a multiple-use packaging, but due to time limits, the interviews could not be redone. Also, I did not want to disturb the interviewees by asking for another interview.

To gather information only one professional per stakeholder was interviewed. This is a restriction in the objectivity of the information because the information is not compared to other points of view of other professionals. This implies that the retrieved information from the interviews needs the be reconsidered when used as a reference for packaging solution.

The environmental contribution of each stakeholder was found through literate research, as by the company with whom this project started. At the beginning of the project, the complete fruit and vegetable sector was explained and mapped by the owner of "Kordaat Product Design".

The end-of-life methods of incineration and landfill were analysed, but put in the appendix. The packaging solution is to be reused or recycled, which is why the other end-of-life methods became less important. Also, the analyses of those methods did not create valuable insights.

6.10 Key findings fruit and vegetable journey

- The weight of the packaging influences the carbon footprint of transport in the entire life cycle of a fruit or vegetable. Unpackaged fruits and vegetables are more efficient in transport, this could change the way mushrooms are sold in most supermarkets.
- To make the recycling rate higher, the packaging should be kept clear of stickers and printed advertisements. The information on the packaging should be displayed via another way.
- The consumer should be supported and informed on how to sort waste, this to increase recycling rates.
- With chemical recycling virgin material can be created from packaging waste, even if its contaminated. This process can make packaging be recycling into food packaging, which saves the manufacturing of virgin materials.
- To make the recycling rate higher and to support the consumer in the sorting process, the packaging should be made of one material.

7. Developments and trends

In this phase of the report, developments concerning packaging, packaging technologies, and grocery shopping experiences are identified. Past developments are researched for inspiration and to see what has been done. Also, to see if the packaging solution may be combined with a development. Next, to research into what has been done already, it is also researched which trends are currently in movement. The trends are analyzed to anticipate the consumers its demands and wishes in the coming years, from which demands and wishes can be retrieved. Research into the future situation in the economy, technology, and consumer behavior is performed. In the first chapter, a timeline is presented with establishments in processes, technology, and materials. In the second chapter, the trend analysis is performed.

1970	1976	The one piece polyethylene shopping bag is designed an patented [3]
	1976	Introduction PET bottles [1]
	1977	First barcode used in supermarket [2]
1980	1979	The plastic shopping bag controlles 80 per cent of bag market in Europe [3]
	1987	Introduction ordering groceries by phone, in Albert Heijn [4]
	1988	First payment with debit card [5]
1990		
	1990	PLA commercialy available [6]
	1994	Introdution James Telesuper, first way to order groceries via the computer [4]
	1997	Prohibition landfill of certain goods in the Netherlands [7]
2000		
	2000	PLA used as packaging material [10]
	2001	Introduction AH webshop [4]
	2003	Introduction self scan technology in supermarket [8]
	2006	Prohibition on free plastic bags in stores [9]
	2009	Introduction supermarket app, the "Appie-app" [4]
2010	2010	European union subsidizes laserbranding project fruits and vegetables [11]
	2011	Opening Deka Drive, first collection counter supermarket [4]
	2012	1-2-klik HAK lid introduction [12]
	2014	contactless payment [13]
	2015	PICNIC first delivery, first online only supermarket, that delivers from a wholesaler [4]
	2017	Laserbranding technology introduced in supermarket [14]
2020	2018	Start build first plastic waste chemical recycling factory in the Nethelands [15]
	2021	Goal to start the chemical recycling factory [15]

Figure 35: Timeline of developments throughout the years.
Note: The references of the time table are presented separately in the references

7.1 Developments

In the developments analysis is researched which developments have led to the current situation of food packaging, food selling, and disposal. The information retrieved in this chapter is used as inspiration for the ideation, and as reference for the packaging vision. Figure 35 shows a time-line of the developments throughout the years.

Polyethylene Terephthalate bottles were introduced in 1976 and are still being sold (Yam, K, 2009). It can be seen that paper packaging was replaced for plastic packaging in the eighties, however from the year 2000 developments started into sustainability. Free plastic bags in stores were prohibited and biodegradable material was introduced. In 2017 a process was developed that could brand in branding (Rensen, 2017). This technology could replace branding stickers and may even replace bar code stickers in the future.

In ways of disposal a movement is in progress. In the Netherlands in the year 1997 a prohibition of landfill of certain goods was set (Overheid.nl, 1997). Residual household waste is part of this prohibition. The developments have let the development of chemical recycling in which virgin material can be produced from plastic waste. The movement is to get as much material back, to save production of new virgin material, which contributes to a positive environmental impact.

Form 1978, different ways to sell groceries were developed. The Albert heijn has been one of the leading innovative supermarkets in development, which has led to a web shop and an app. A start up has taken it a step further by selling groceries without having an actual building and food stocks (Meijsen, 2018). A movement is seen in which more and more food products are sold online. This statement is deducted by the observation of making online shopping more convenient throughout the years.

To conclude, throughout the years developments were made to make packaging more sustainable. New developments have led to ways of disposal that may exclude the production of new virgin material from resource. The developments, also led to technology that can laser print branding in fruits and vegetables its peal, which could save promotional stickers. Throughout the years online grocery shopping is developed, which has led to the start up of an online only grocery shop.

7.2 Trend analysis

In this chapter trends are researched, analysed and discussed. This is performed to anticipate the packaging solution to future developments. To set up the research, the “Trend analyses” method written by Van Boeijen, Daalhuizen, Zijlstra, and Van der Schoor (2014) was observed. The trend analyses was done at the end of the analysis phase of this project, because more focussed trends can be searched now.

In this trend analysis, the DEPEST method is used. However, the focus of this project is lowering the environmental impact of packaging waste and maintaining or improving the consumer experience with a reusable packaging solution. This is why only Social (S) and Technological (T) trends are researched and analysed. Ecological trends were already discussed in previous chapters, it was discovered that less plastic is used, and that the government invest in informing the consumer about sorting waste. This focus is done to limit the search.

Social trends

- Local for local: An upcoming trend in which only food is eaten, which is grown in the region (Beverloo, 2013). This saves significantly in transport and can have positive influence on the trust of consumers in the food.
- The Dutch consumer becomes more sustainable aware, which is why more interest is raised in how food is produced (Rabobank, n.d.). This could mean that the consumer may be more willing to buy sustainable products and packaging after reading into food production.
- There is a growing demand for organic products (Kearney, 2010). Also, The consumer demands fresh products and more sustainable products (Poel, 2016). From these trends is dedected that the consumer becomes more aware of the food they buy, this could mean that the consumer wants to see the product before its packaged to see the quality. If fruits and vegetables are not prepackaged, transport to the supermarket is more efficient.
- Health-conscious consumers want food that is convenient fresh and healthy (Osman et al., 2014). Time is an important factor on the convenient perception of food.
- Online sells will rise because of cross channel shopping (Erich, 2012). The consumer receives more information about the products, and the retail stakeholders obtain more information about the consumer on which they can anticipate, for example with purchase of food stock.
- It is predicted that online shopping of groceries will rise from 1,6 per cent in 2016 to 25 per cent in 2030 of the total supermarket sales in the Netherlands (Van Leusden, Van Tellingen, & Van der Weerd, 2017). Other research tells it will rise less quickly. At least, till 2030 it can be concluded that consumers prefer to go to the supermarkets to buy food.

Analysis social trends:
From the social trends, it is deducted that the consumer wants healthy food that is convenient. To communicate the health benefits of the food more information about the production of the food should be given. Local grown food could benefit in the perception of trust to the consumer of healthy food. While online shopping is increasing popularity, most consumers still prefer to go to a grocery shop.

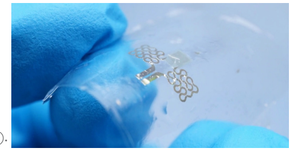


Figure 36: Edible RFID tag (Coldewey, 2017).

Technological trends

- RFID (Radio Frequency Identification) chips are an uprising technology in the food industry, it can for example replace bar codes (Kumari, Narsaiah, Grewal, & Anurag, 2015). Also, Edible RFID tags, these could inform multiple stakeholders about expiry date and remaining shelf-life (Grunow & Piramuthu, 2013), (Figure 36). The RFID tags have multiple information opportunities.
- Smart-phones become more common in personal as professional spheres (Robinson et al., 2013). In combination with QR- scanning codes, NFC or bluetooth low energy technology (BLE) (Packaging World, 2016). This integration of technology can make grocery shopping more interactive, by sharing of information about food products as packaging information.

Analysis technological trends
The technological trends can all stimulate each other. The technology will enable to give more information about the food, to which cross channel communication can play a role in preventing food waste. The consumer can also be informed about sustainability, which can be done through the smart phone that keeps getting more advanced. A future direction could be that the consumer is given the ability to check the quality and availability of the fruits and vegetables at the supermarket from their smart phone. So they could adapt their buying behaviour to the available stock.

Combining social and technological trends
The consumer wants more healthy food and more transparency in the production processes. This can be achieved with an RFID tag. However, the consumer may get concerns about edible tags. Healthy food and RFID tags can contradict each other. The smart phone can be the platform to inform the consumer, about food processes and health benefits. It could also benefit the consumer, by giving the opportunity to see the distance of where the food is produced, which could be interesting, if the food is produced locally.

Conclusion
To conclude, now and in the future the consumer wants more transparency in the production processes of food. Also, they want more healthy and fresh food. Smart phones keep developing, as are the functions they fulfil. A trend in the future could be more locally produced foods, which the consumer tracks by using their smart phone while doing groceries. The RFID tags are increasing in the food sector and can give transparency in food benefits to the consumer. It was also concluded that till 2030, most of the consumers prefer to go the supermarket, instead of ordering groceries online. The period for which the packaging solution is designed, is therefore set from now to at least 2030.

7.3 Key findings developments and trends

- A movement is going on in which less plastic packaging is offered, and the plastic that is offered is going to be recycled into virgin material in the future.
- RFID tags and laser branding into the peal of fruits and vegetable are replacement options of Stickers with bar codes and stickers with branding.
- While the share in online grocery shopping is growing, most of the consumer will continue to buy groceries ate the supermarket, at least till 2030.
- Transparency is asked by the consumer to get more knowledge about the processes concerning food and to get more trust in the health benefits of food.
- During the years, grocery becomes more convenient, as does the paying process as well, By evolving from cash to contact-less payment.
- Smart phones will get a more dominant position in the future in personal as professional spheres.

8. Overview key findings

Environmental findings

- A balance need to be found between shelf life and the need for packaging.
- Some of the current packaging have packaging features, which are fit for a reusable packaging but the current packaging are single used. Greenhouse gasses can be saved if packaging only have the necessary features for the times of usage.
- Is pre-packaging still the most sufficient way of supplying and selling mushrooms, when looking at the complete supply chain? Transport of unpackaged fruits and vegetables can be more efficient.
- The weight of the packaging influences the carbon footprint of transport in the entire life cycle of a fruit or vegetable. Unpackaged fruits and vegetables are more efficient in transport, this could change the way mushrooms are sold in most supermarkets
- To make the recycling rate higher, the packaging should be kept clear of stickers and printed advertisements. The information on the packaging should be displayed via another way.
- With chemical recycling virgin material can be created from packaging waste, even if its contaminated. This process can make packaging be recycling into food packaging, which saves the manufacturing of virgin materials.
- A movement is going on, in which less plastic packaging is offered and the plastic that is offered is going to be recycled into virgin material.
- To make the recycling rate higher and to support he consumer in the sorting process, the packaging should be made of one material.

Consumer behaviour

- Buying behaviour is changing, less plastics packaging is found in the household waste. (Trend)
- Consumers are willing to do and pay more for sustainable products. (Trend)
- The preference of the consumer for a blue mushroom packaging is shifted to a transparent or other another coloured packaging.
- Consumers relay on material and material volume to make a judgement on a packaging its sustainability
- Colour is taken into consideration when determining a packaging its sustainability.
- The consumer looks at convenience of the packaging, and quality of the fruit or vegetable when buying fruits and vegetables.
- Easy of resealing, easy to open, and packaging size are packaging buying considerations of consumers.
- To involve the consumer in sustainable behaviour concerning packaging, they should be informed more about sustainability aspects of packaging.
- Consumers lack knowledge to discover all packaging features if no use cues, or text is available. The consumer should be informed more about the packaging itself.
- The consumer should be supported and informed on how to sort waste, this to increase recycling rates.
- Consumer threshold values of reusable food products are; no room for storage of the products and skill in filling of the product.

Mushroom findings

- Mushrooms are vulnerable to: Mechanical damage (pressures on the mushroom), temperature, humidity levels, carbon dioxide concentrations.
- Mushroom are a delicate vegetable, the consumer knows this, and pays attention to where to place the packaging during grocery shopping. This to remain the quality of the mushrooms.

Context findings

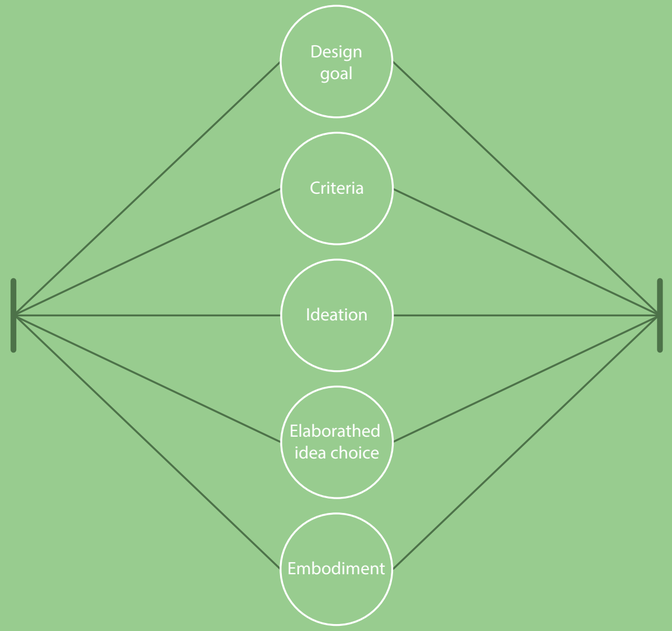
- Supermarkets are not adapted to reuse of packaging, most of the packaging are single-use products.
- With a reusable packaging solution the information normally presented on the packaging needs to be presented in another way.
- Reusable packaging has threshold values for consumers that can be over-won by designing the context next to the packaging as well.
- While the share in online grocery shopping is growing, most of the consumer will continue to buy groceries ate the supermarket, at least till 2030.
- Transparency is asked by the consumer to get more knowledge about the processes concerning food and to get more trust in the health benefits of food.

Technology findings

- Smart systems with big data analyses can prevent food and packaging waste.
- RFID tags and laser branding into the peal of fruits and vegetable are replacement options of Stickers with bar codes and stickers with branding.
- During the years grocery shopping becomes more convenient, as does the paying process. By evolving from cash to contact-less payment.
- Smart phones will get a more dominant position in the future in personal as professional spheres.

Reusable packaging findings

- Pre-packaged food products have a set volume of food, which not always complies with the needed amount by the consumer. Put the consumer in charge of taking the desired volume of food.
- A way to keep materials together as the food inside the packaging is taken out, is by having a lid which is part of the packaging, this makes the experience more simple and convenient for the consumer as well.
- Top seal packaging and a foil around a basket are currently pre-packaged products, but putting the seal or foil on the packaging in the supermarket, food spillage can be decreased or even prevented.
- The consumer perceives cardboard as a more sustainable material than plastic.
- Another way of using the blue mushroom basket is as temporarily waste bin.
- Most inconveniences come from opening and resealing a packaging.



02| Synthesis

9. Translation of the analysis phase into an elaborated idea

9.1 Design goal

Before starting the ideation, the assignment of this project is revised. The analyses in combination with the set assignment of this project form the base of the design goal. In this chapter, the design goal is defined to which the ideation and the choosing for a elaborated idea is focussed.

The original assignment of this project is:
"Design a packaging solution for the fresh fruit and vegetable sector that creates a lower environmental impact over its lifetime than the current packaging situation, in which a packaging is only used once as a food packaging and then disposed of. The packaging solution should maintain or improve the consumer experience while being reusable by the consumer, at least once."

According to chapter "8. Overview key findings", the consumer has multiple criteria in buying and using packaging, which are based inconveniences. The threshold values of consumers towards reusable packaging are: filling of the reusable packaging, no room for storage of bulk of packaging, and that the context (the supermarket) is not adapted to reusable products.

"The packaging solution designed in this project, is either reusable for the same purpose or another purpose and the packaging solution must be adapted to the consumer's wishes, by taking away the threshold values and inconveniences related to reusable packaging"

Figure 37: design goal.

The focus of the ideation is to take away inconveniences and threshold values of using a reusable packaging. By making consumers use a reusable packaging, the environmental impact of packaging is lowered. The design goal of this project, revised by the analysis phase is shown in figure 37. The packaging solution will be designed for, now until at least 2030 (chapter "7.2 Trend analysis").

9.2 Criteria

The reusable packaging solution needs to meet certain requirements. By setting requirements a packaging solution is designed, chosen and optimised, to fit the assignment of this project as well as possible. The requirements are made of facts and insights retrieved from the chapters in the analysis phase. The requirements and wishes are presented as a checklist. The requirements are points that have to be met by the packaging solution and the wishes are points that do not need to be met. The checklist is based on the checklist for the list of requirements from Roozenburg & Eekels (Roozenburg & Eekels, 1998). The requirements are numbered and categorised on importance per category. After each requirement and wish, is the chapter noted from which it is deducted.

The importance of the criteria is based on relevance to the design goal. First, the criteria concerning reuse are stated, because the objective of this project is designing a more sustainable packaging solution for the fruit and vegetable sector by making it reusable. The other part of the design goal is maintaining or improving the consumer experience with reusable packaging, which is why these criteria are stated after the criteria concerning reuse. The ranking in the importance of the criteria is done because these are used in the ideation phase to decide between ideas. Also, at the end of the ideation a selection of the criteria is used to make a decision between the elaborated ideas.

Requirements

1. *Performance*

1.1 The packaging solution must be reusable by the consumer, at least once.

1.2 The packaging must be resealable by the consumer multiple times (Chapter “5. Consumer research”)

1.3 The packaging must be convenient in filling of the packaging. (Chapter “5. Consumer research”)

1.4 The packaging solution must be able to keep the fruits or vegetables together. (Chapter “4.1 Packaging market”)

1.5 The packaging must provide protection from impact from other groceries, during transport by the consumer from the supermarket to the home of the consumer. (Chapter “5. Consumer research” and chapter “4.5 The Mushroom”)

1.6 The product must be self-explaining, the consumer must understand all its function within 5 minutes. (Chapter “5. Consumer research”)

1.7 The packaging must be able to regulate moist levels, by an absorbing material or by air-holes and/ or packaging structures. (Chapter “4.5 The Mushroom”)

1.8 The packaging solution, must keep the mushrooms safe from external biological and chemical influences (Chapter 4.1). At least, until the consumer has unpacked the fruits and or vegetables.

1.9 The consumer must be able to pick the desired amount of fruits and vegetables themselves. (Chapter “3. Background packaging waste”)

1.10 The packaging solution must be resistant against temperatures inside as outside the fridge (Chapter “4.4 Fruit and vegetable focus”)

2. *Maintenance*

2.1 The packaging solution must be constructed in a way that it can be cleaned by the consumer, within 5 minutes. (Chapter “5.9 Reusable packaging perception literature research”).

3. *Shape, colour, finishing*

3.1 The consumer must be able to see the fruits and vegetables before buying them, either through the packaging or before packaging. (Chapter “5. Consumer research” and chapter “4.8 Design thoughts behind the iconic blue mushroom container”)

5. *Materials and technology*

5.1 The technology must be implemented in a way that the consumer can use it without finding it inconvenient. (Chapter “5. Consumer research”, adapting the context to reuse, and informing the consumer)

5.2 The packaging material must be kept clear from stickers. (Chapter “6.7 The disposal company”)

6. *Storage*

6.1 The packaging must be able to decrease in size, by either stacking of packaging or being able to making the actual packaging smaller. (Chapter “5. Consumer research” and chapter “6.8 Overview findings per stakeholder”)

7. *Safety*

7.1 The material of the packing solution may not be harmful or toxic for the fruits and vegetables in a solid state.

7.2 The packaging solution must comply with food safety regulations

8. *Information system*

8.1 Presents the consumer with information about the fruit of vegetable and its production process. (Chapter “7. Developments and trends analysis and chapter “5. Consumer research”)

8.2 Presents information about sustainability in packaging. (“5. Consumer research”).

9. *Certificates and regulation*

9.1 The given information must at least have as much information as the current mushroom packaging. (Chapter “4.6 Information on a mushroom packaging”)

10. *End of life*

10.1 The packaging solution must not generate more waste than the current grocery shopping situation, in which a combination of pre-packaged and unpackaged food products are sold. (Chapter “3. Background packaging waste”)

10.2 The material of the packaging solution must be recyclable by mechanical recycling. (Chapter “6.7 The disposal company”

Wishes

W1.1 Could be implemented to package all fruits and vegetables that need packaging.

W1.2 The packaging can be used for multiple purposes.

W1.3 Minimize waste to zero waste. (Chapter “3. Background packaging waste”).

W1.4 The packaging must have the ability to have 1 kilogram of groceries on top of the packaging solution.

W1.5 The fruit and vegetables must retain inside the packaging when it is dropped from 1 meter.

W1.6 Integrate the smart phone in the packaging experience. (Chapter “7. Developments and trends analysis”)

W1.7 Information about the usage of the packaging must be available to the consumer. (Chapter “5. Consumer research”)

W1.8 Prevent food waste by exchange of data between the consumer and the supermarket (Chapter “3. Background packaging waste” and chapter “7. Developments and trends analysis”)

W1.9 The packaging solution must be suited for chemical recycling. (Chapter “6.7 The disposal company” and chapter “7. Developments and trends analysis”)

9.3 Ideation approach

From the findings in the analyses phase and the design goal, a structure is made that represents the ideation process (Figure 38). From the design goal elaborate ideas are made, from which one is selected at the end of the ideation. Creative sessions were done on my own as with three other master industrial design students.

To get the participants involved into the topic of this project, an introduction speech was performed. The participants were asked to create ideas on "How-To's", which are small sub-questions, created from the design goal and retrieved insights of chapter "8. Overview key findings". The following "How-To's" were performed by me as by the participants:

Reuse: How-To...
- Reuse a packaging (as what can we reuse it)
- Give feedback to consumer?
- Get a packaging back?
- Make a packaging solution interactive?
- Save material?
- Weigh an fruits and vegetables precise?

Convenience: How-To...
- Re-seal a packaging?
- Combine properties from a bag and a hard plastic box?
- Make something decrease in size?
- Make fruit and vegetable packaging filling at supermarket more convenient?
- Make a packaging more convenient?

These "How-To's" were used, and if a promising idea came up in between, it was saved and ideated more later.

The packaging solution created in this project takes the fruit and vegetable chain in consideration, which is organised in a "Morphological chart" (Figure 39). The theory behind the chart was retrieved from Van Boeijen, Daalhuizen, Zijlstra, and Van der Schoor (2014). In this project, the chart is more used as overview than to make directions into which an ideation is done.

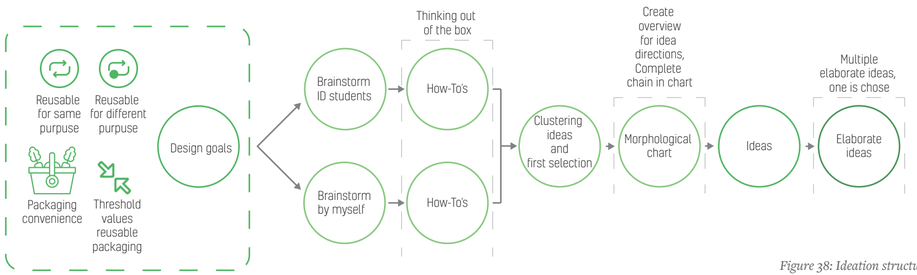


Figure 38: Ideation structure.

9.4 Ideation

This chapter represent the journey of the fist phase of the ideation.

In appendix V A, the "How-To's" are presented that are stated in the previous chapter.

From all the ideas generated in the "How-To's" and brainstorm sessions, a selection was made and a morphological chart created. The chart represents the ideas for different stages of the fruit and vegetable its life cycle. The ideas in the morphological chart are selected on potential for reuse, convenience is use, originality and feasibility. In this phase of the ideation more general criteria was used to make sure convergence of ideas does not take place to fast, which can limit the creativity of ideas. This morphological chart gives an overview of possible directions and is a summarized chart of potential ideas (Figure 39). Three of the ideas on the next pages are deducted from the direction showed with the coloured lines in morphological chart.

The ideas are created by making combinations from the morphological chart as by free brainstorming. The ideation is set-up in two directions:
- Reuse for the same purpose
- Reuse for a different purpose

On the next pages the ideas from the ideation described above are presented. For each of the ideas positive and negative points are noted. The criteria used to make these positive and negative points are derived from

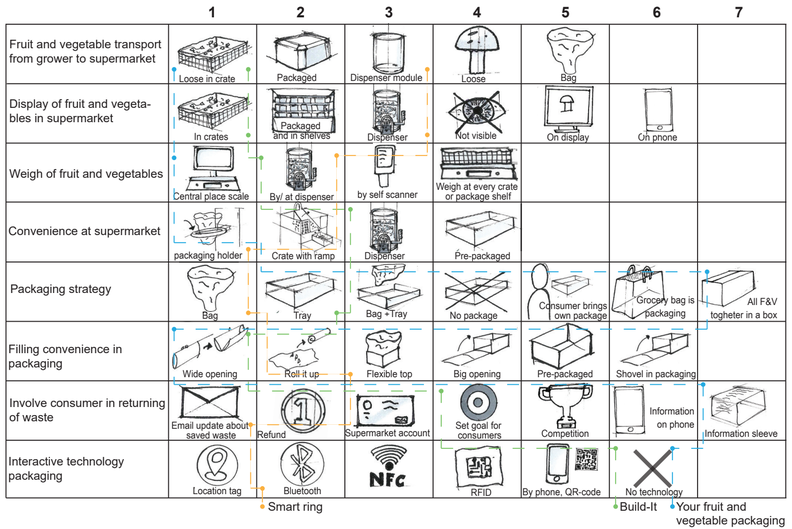
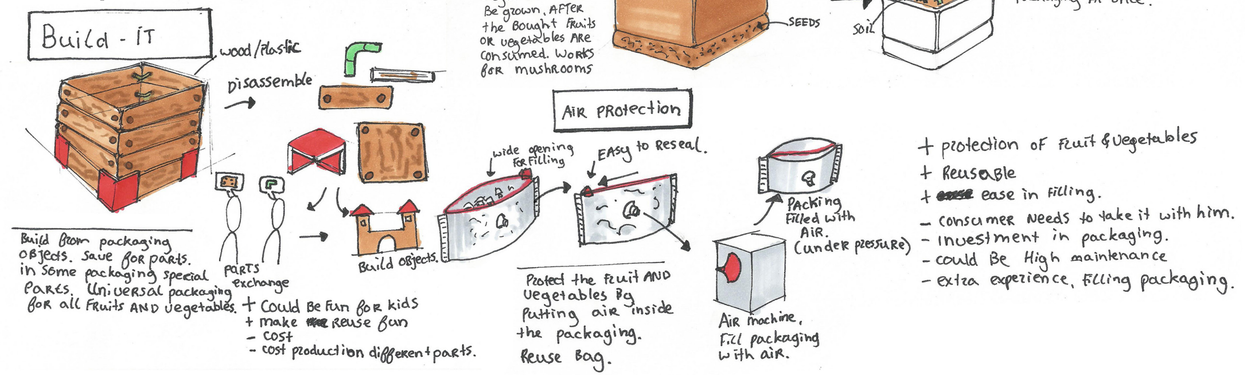


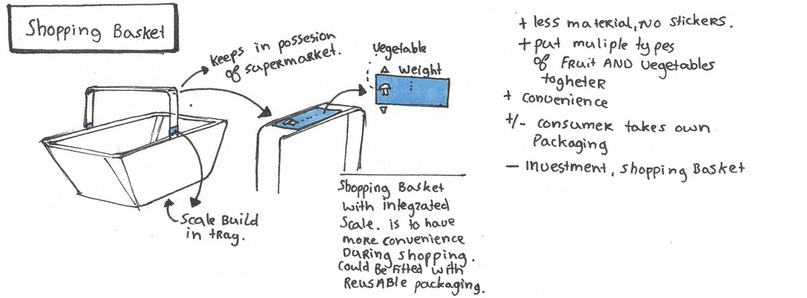
Figure 39: Morphological chart

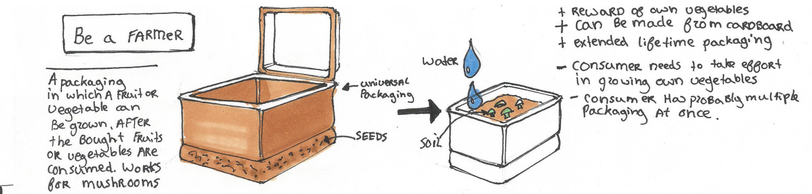
the criteria noted in chapter “9.2 Criteria”. After each of the criteria the reference number from chapter “9.2 Criteria” is noted. The used criteria are noted and ranked on importance.

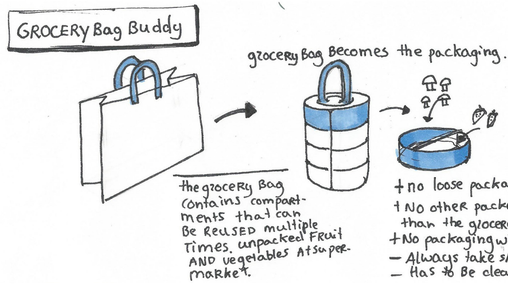
The following criteria were used to evaluate the ideas on this page and the next:

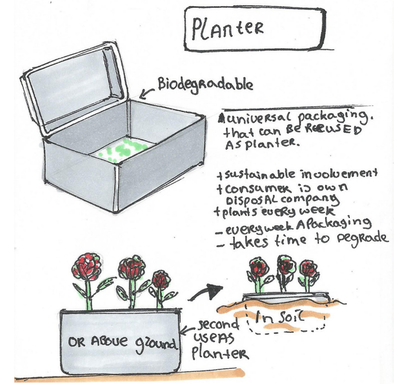
- The reusability of the idea. Can the idea be used multiple times for the same purpose or does it extend the lifetime by reuse for another purpose. (1.1 and 1.2)
- The potential savings in waste. (10.1)
- Convenience in the filling of the packaging, does it require a high skill level in the filling process. (1.3)
- The amount of storage space needed, can the idea decrease in size. (6.1). Also taken into account the amount of packaging that need to be stored.
- The energy in maintance of the idea, specifically in cleaning it. (2.1)
- The potential investment for either the consumer or the supermarket

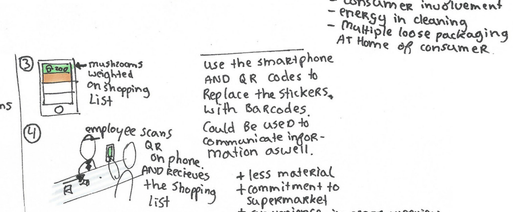


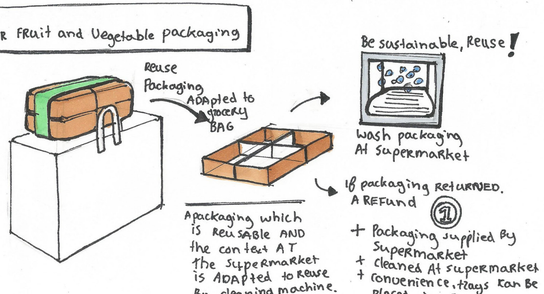












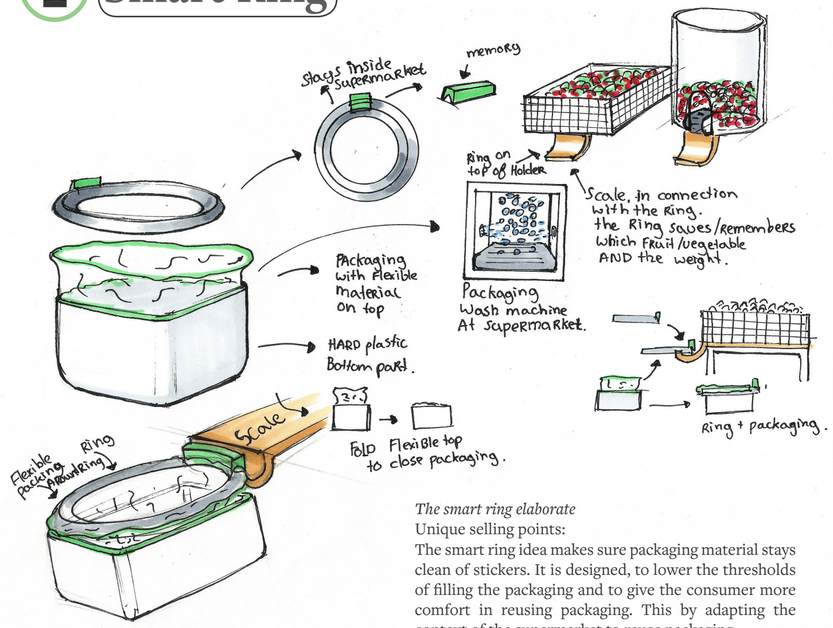
Some of the ideas on the previous pages can be combined. By combining ideas more life cycle phases of a fruit or vegetable its journey are covered. For example the "grocery bag buddy" can be combined with the "keep packaging material clean". The build-it can be combined with an build competition app or system. To make the elaborate ideas, the ideas above were combined. Each of the combinations then judged with the criteria stated on page 69. The three most promising elaborate ideas are described in the next chapter.

9.5 Elaborate ideas

In this chapter, the elaborate ideas are presented. From each of selected elaborate ideas the following elements are noted:

- Unique selling point
- Conveniences from analysis phase
- Potential issues
- Potential environmental savings
- Scenario

1 Smart Ring



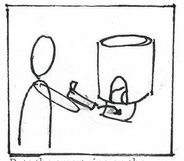
The smart ring elaborate

Unique selling points:

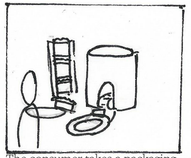
The smart ring idea makes sure packaging material stays clean of stickers. It is designed, to lower the thresholds of filling the packaging and to give the consumer more comfort in reusing packaging. This by adapting the context of the supermarket to reuse packaging.

Conveniences:

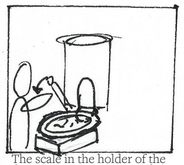
The consumer walks into the supermarket and takes a smart ring



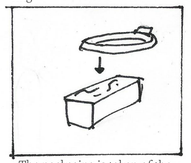
Puts the smart ring on the specialy designed ring holder on the dispenser



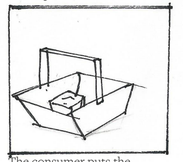
The consumer takes a packaging and folds the flexible part round the smart ring



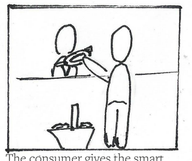
The scale in the holder of the dispenser communicates the weight and type of fruit or vegetable to the smart ring



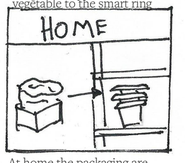
The packaging is taken of the smart ring, and the packaging folded shut.



The consumer puts the packaging in the shopping basket



The consumer gives the smart ring to the employee at the counter, who reads the data on the smart ring with the computer. The consumers shopping list appears on the screen of the employee. The consumers pays.



At home the packaging are stored after the fruit and/ or vegetables are consumed.

The next time the consumer goes to the supermarket, the packaging can be cleaned in a machine. The packaging can be reused by the consumer.

- Ease in filling of the packaging, because of wide opening top part of the packaging.
- The consumer can take the desired amount of fruits and vegetables.
- Convenient resealing, by folding the flexible part of the packaging.
- Cleaning of the packaging takes place at the supermarket.

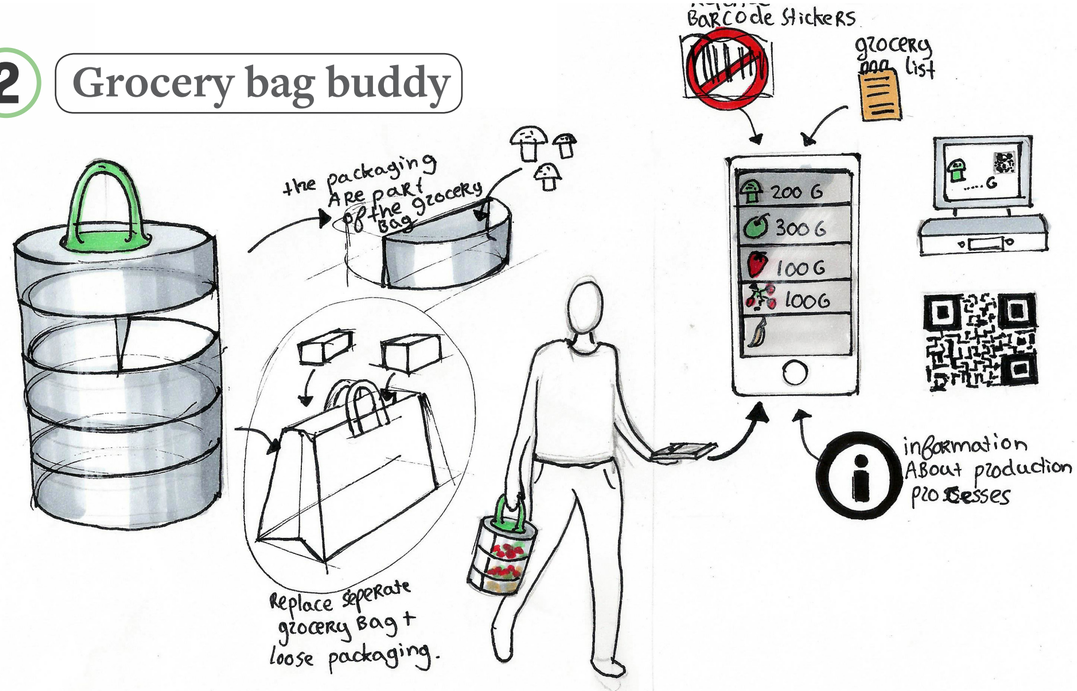
Potential issues:

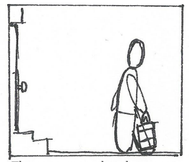
- The consumers walks around with a smart device, which could be damaged by impact.
- The consumers must be sustainable involved, to be convinced to reuse the packaging.
- Consumers can put more fruits and vegetables in the packaging, after the ring is taken of the scale.
- The consumer has the threshold of storing multiple packaging at home, with this solution multiple packaging may be stacked at home.

Potential environmental savings:

The ring saves material of stickers, and if the packaging is reused it saves material and production of virgin materials. The smart ring can activate people to become more involved in sustainable packaging and/ or sustainable grocery shopping.

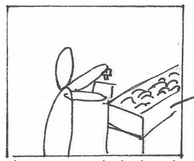
2 Grocery bag buddy



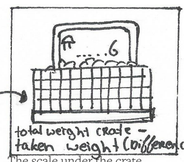


The consumer takes the grocery bay buddy from home to the supermarket

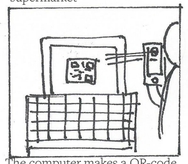
At the supermarket, the consumer takes one of the packaging from the grocery bag buddy



The consumer picks the desired amount of fruit of vegetables, and puts it in the packaging

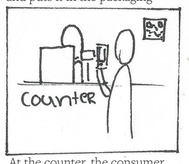


The scale under the crate calculates the weight of fruits and vegetables taken from the crate



The computer makes a QR-code that is scanned by the consumer with his or her smartphone. The app creates the shopping list

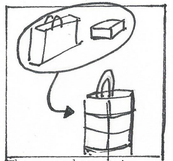
The consumer puts the packaging back in the grocery bag buddy



At the counter, the consumer presses "finished" in the app, and a QR-code is made. The employee of the supermarket scannes the bar code and the shopping list of the consumer appears on the screen. The next step for the consumer is to pay for the groceries.

At home, the consumer takes the packaging and put them if necessary inside the fridge.

When the fruits and/ or vegetables inside the packaging are consumed, the consumer puts it bag in the grocery bag buddy.



The grovery bag solution replaces the conventional grocery bag and loose packaging for one product.

The grocery bag buddy

Unique selling points:

The grocery bag buddy is a packaging solution focussed on convenience in reuse. It combines packaging and the grocery bag in one product.

Conveniences:

- Ease in filling of the packaging.
- The consumer can take the desired amount of fruit or vegetables.
- Convenient resealing, by putting the packaging back in the grocery bag buddy.
- The app makes paying at the counter easier, because the packaging does not have to be taken out of the grocery bag buddy.
- No loose packaging at home when the fruits and vegetables are consumed, because they can be placed back in the grocery bag buddy.

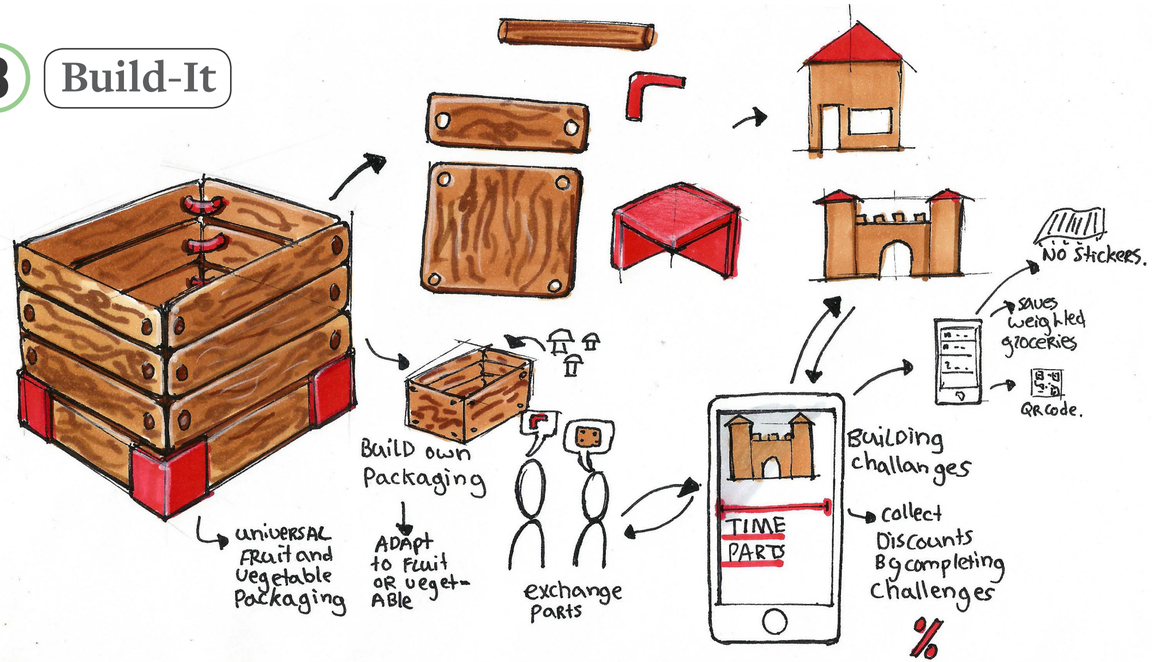
Potential issues:

- The consumer is obliged to use their smart phone.
- The consumer can take more fruits and vegetables after the QR-code is scanned.
- The cost to purchase the grocery bag buddy may be a threshold for consumers.

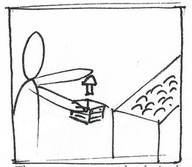
Potential environmental savings:

The grocery bag buddy saves packaging because it can be reused multiple times. The grocery bag buddy also saves grocery bags, if it has a longer lifetime than multiple conventional grocery bags. The app makes it possible to eliminate barcode stickers. This elaborate idea saves the production of virgin material and sustainable impacts by end-of-life methods. Packaging waste can be saved by the grocery bag buddy.

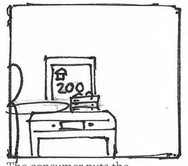
3 Build-It



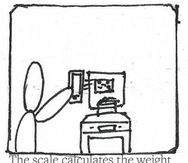
At the supermarket the consumer takes a build-It packaging.



The consumer puts the desired amount of fruits and/or vegetables in the packaging

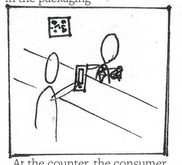


The consumer puts the packaging with the fruits and vegetables on the scale.

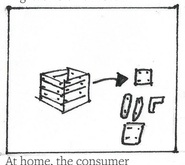


The scale calculates the weight and creates an unique QR-code, that can be scanned with the app on the smart phone.

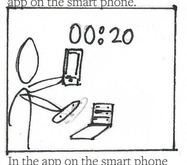
The smart phone app makes a grocery list from the scanned QR-codes, with the weight of the taken fruits and vegetables.



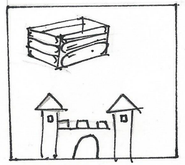
At the counter, the consumer presses "finished" in the app, and a QR-code is made. The employee of the supermarket scans the bar code and the shopping list of the consumer appears on the screen. The next step for the consumer is to pay for the groceries.



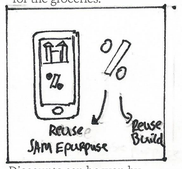
At home, the consumer disassembles the packaging.



In the app on the smart phone are challenges to create objects with the parts of the packaging.



The challenge can be to make, for example, a castle, but the consumer can also be challenged to make another packaging. The consumer can also make a packaging on their own that fits their needs better.



Discounts can be won by completing challenges.

The Build-It

Unique selling points:

A packaging solution that is designed to be fun, and by challenges makes the consumer reuse the packaging. The packaging can also be changed in a packaging that fits the wishes of the consumer better.

Conveniences:

- Ease in filling of the packaging.
- The consumer can take the desired amount of fruit or vegetables.
- The app makes the time at the counter shorter, because all the groceries are saved in the app. This is also done with a self scan in current grocery stores.
- The packaging can be disassembled in storage.

Potential issues:

- The consumer is obliged to use their smart phone.
- The consumer can take more fruits and vegetables after the QR-code is scanned.
- Some consumers may not like to build, or do not have children to give the packaging to.
- If the consumer throws away the packaging, it has probably a bigger environmental impact than the current single-use packaging.
- The consumer may find it to much parts after buying one or multiple packaging every week.

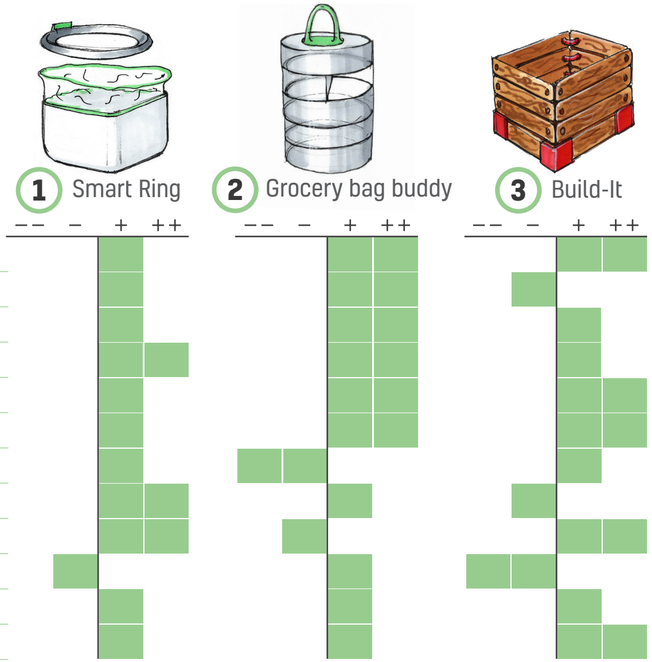
Potential environmental savings:

The build-It can be reused as packaging, as it can be reused to build objects. Both these options extend the lifetime of the packaging, which makes it more sustainable. The app makes it possible to eliminate barcode stickers. This elaborate idea saves the production of virgin materials and sustainable impacts by end-of-life methods. The build-It could save packaging waste.

9.6 Selection elaborate idea

Requirements

1.1	The packaging solution must be reusable by the consumer, at least once.
10.1	The packaging solution must not generate more waste than the current grocery shopping situation.
1.2	The packaging must be resealable by the consumer.
1.3	The packaging must be convenient in filling of the packaging.
1.4	The packaging solution must be able to keep the fruits or vegetables together.
1.5	The packaging must provide protection from impact from other groceries during transport by the consumer.
6.1	The packaging must be able to decrease in size, by either stacking of packaging or being able to making the actual packaging smaller.
3.1	The consumer must be able to see the fruits and vegetables before buying them, either through the packaging or before packaging.
2.1	The packaging solution must be constructed in a way that it can be cleaned by the consumer within 5 minutes
1.6	The product must be self-explaining, the consumer must understand all its function within 5 minutes.
5.1	The technology must be implemented in a way that the consumer can use it without finding it inconvenient.
10.2	The material of the packaging solution must be recyclable by mechanical recycling.



To make a decision between the three created elaborate ideas a “Harris-profile” was used (Van Boeijen, Daalhuizen, Van der Schoor, & Zijlstra, 2014). This method makes an overview of how each elaborate idea fits the set requirements and wishes, form with the best option can be chosen. The elaborate ideas are judged on a summarized list of the list of criteria in chapter “9.2 Criteria”. The used criteria are ranked on importance, Starting with the most important criteria. In chapter “9.2 Criteria”, it is explained why certain criteria are more important than the other. The Harris-profiles are presented above.

From the Harris-profiles, it is observed that the “Grocery bag buddy” fits the requirement best. The advantage of the “Grocery bag buddy” is that multiple fruits and vegetables can be packaged in one product. The other two elaborate ideas are build of separate packaging for each fruit or vegetable, which means multiple packaging are collected when doing groceries, while the “Grocery bag buddy” is all packaging contained in one product. Another advantage of the “Grocery bag buddy” is that it minimizes the packaging waste, by being the grocery bag and packaging in one.

Conclusion

To conclude, the “Grocery bag buddy” is the elaborate idea with which is proceeded in this project. Because it fits the requirements and wishes best, and has the most potential advantages.

Discussion

To make a decision between the elaborated ideas Harris-profiles were used. The assessments of the elaborated ideas on the criteria are intuitive. This because not all the details of the elaborated ideas are worked out. This is why they are called elaborated ideas instead of concepts. A prediction of the performance needed to be done at for example the criteria about easy in filling of the packaging and performance in the cleaning of the packaging. If the tree elaborated ideas were more detailed in how they are constructed and how they work, more substantiated scores could have been given. The grocery bag buddy scores best in the ranked more important criteria, which is why it is chosen over the other elaborated ideas.

10. Embodiment

To develop the elaborate idea of the grocery bag buddy into a concept, it is embodied. The elaborate idea consist of a grocery bag solution and a smartphone app and a scale, which all are designed in the coming chapters. First, a customer journey with the new grocery bag solution is sketched. This to see what features need to be designed, where insecurities lay, and what paths the consumer can take when doing groceries. On the data retrieved from this analysis, the embodiment of the grocery bag solution is started. In figure 40, the different parts of the “grocery bag buddy” are illustrated and named.

After the customer journey, the grocery bag buddy is embodied. The smartphone app and scale are embodied in chapter 11.

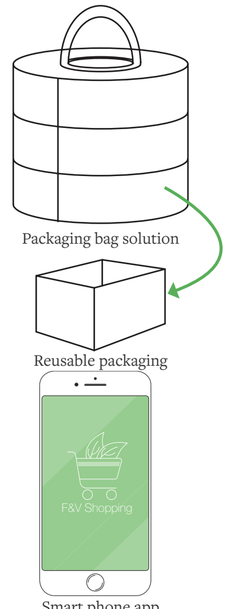


Figure 40: Parts of the grocery bag buddy.

10.1 The Grocery bag buddy introduction

The grocery bag buddy was chosen as the best fitting elaborate idea to the concept. This elaborate idea, consists of a shopping bag with integrated fruit and vegetable packaging. Before starting the embodiment of the grocery bag buddy, features requirements and wishes were set to which the grocery bag solution is designed. This was done by making a customer journey and by reviewing the list of criteria (Chapter 8.3 Criteria"). But first, an explanation of the grocery bag buddy is given.

How it works

The grocery bag buddy is designed with two key findings in mind, "minimizing packaging waste" and "convenient reusable grocery shopping experience". The grocery back has multiple packaging in it to store fruits and vegetables, during shopping and transport. After the product is brought home, the consumer can take the different packaging out of the grocery bag and store them inside or outside the fridge. After the fruit or vegetable is consumed, the packaging can be put back in the grocery bag solution which makes it a complete product again. The grocery bag solution is not a functional product without the packaging, this should activate the consumer to put the packaging back in the grocery bag solution for reuse. The objective is to have a grocery bag solution that can be used for weekly grocery shopping. This saves single-use plastic packaging. To design the grocery bag solution requirements and wishes adapted to the grocery bag solution are set in the chapter "10.3 The Grocery bag buddy additional criteria".

10.2 Customer journey grocery bag buddy

To discover what information is lacking and what additional requirements and wishes need to be noted, specific for the grocery bag buddy, a customer journey was made (Van Boeijen, Daalhuizen, Van der Schoor, & Zijlstra, 2014).

The customer journey is based on a visionary idea. The information retrieved to make the journey is based on my own visions and knowledge. Also, on information retrieved from the interviews in the chapter "5.0 Consumer research", and appendix II. To gather insights into the customer journey of consumers shopping with reusable packaging inside a packaging-free store, research in the graduation report of Meulendijks was used as a reference (Meulendijks, 2016).

In the customer journey, per stage the following questions were asked. This to have a customer journey overview with the asked information:

- Which steps do consumers take with the product?
- What are potential problems?
- What are thresholds of consumers at this stage?
- What is missing and needs to be designed?

During the journey, it is described and questioned what needs to be considered in the design of the "grocery bag buddy". On pages 81 and 82 the customer journey is presented.

Analysis of customer journey

From the research and my own visions it can be deducted, that many questions can be asked at and in-between stages of the consumer journey of the "grocery bag buddy". What needs to be considered is the amount of packaging that fits inside the grocery bag solution. The estimated amount of needed packaging per grocery shopping experience is eight. This is calculated with an average household of 2.2 persons that go to the supermarket twice a week (Deloitte Accountantcy & Advies B.V., 2015), (Centraal Bureau voor de Statistiek, 2018b). In Appendix VI A, the complete calculation is presented with a reflection on the calculation and the result. The estimated eight packaging is a rough estimation that should not be taken as a solid number, because of insecurities in the number of persons per household as the number of fruits and vegetables eaten and bought daily (Appendix VI A). The wish is noted that the grocery bag buddy should at least be able to carry eight packaging with the volume of a 250- gram mushroom packaging, which is 900 cm3 (Chapter "4.3 Packaging materials"). To enlarge the packaging volume, multiple size packaging could be designed and/ or the grocery bag buddy could be made expandable in size, to hold more packaging.

How to carry the grocery bag solution is another question that is not defined. From the customer journey it was found that this knowledge was lackaging. It can be carried on the shoulder, on the back or carrying it by hand. At this point the decision is made to make a requirement that it can be carried by one hand like a conventional grocery bag. A wish is stated, that it can be carried in more ways than only by hand. The conventional grocery bag can be carried by hand and on the shoulder.

The packaging inside the grocery bag solution needs to be designed. Also, theway the consumer holds the packagings needs to be designed, this to make a clear packaging in use and to make convenient experience.
During the filling of the packaging it needs to be held in the hand by the consumer, a requirement derived from this is: The reusable packaging needs to be able to be held in one hand, while filling the packaging with fruits or vegetables.

In the original idea of the grocery bag buddy, a scale is placed under every crate. From the customer journey, the question was raised if this is the most efficient way. This because the scale can also be placed at a central point inside the supermarket. The feasibility and efficiency of a scale under every crate of fruit or vegetables is discussed in chapter ''10.4 The original scale idea".

It needs to be thought of, what to do when the consumer wants to return some of the fruits and vegetables after he or she scanned the QR-code on the screen of the scale. This needs to be thought of and is covered in the embodiment of the smart phone app.

If the consumer wants to take more fruits and vegetables, he or she can go back and start the picking and weighing process again. It would be ideal if the amount would be automatically added to the already scanned amount of fruits or vegetables. When the consumer wants to return part of it, there should be designed a separate option, in which the fruits or vegetables that are put back are automatically deducted from the previously taken amount.

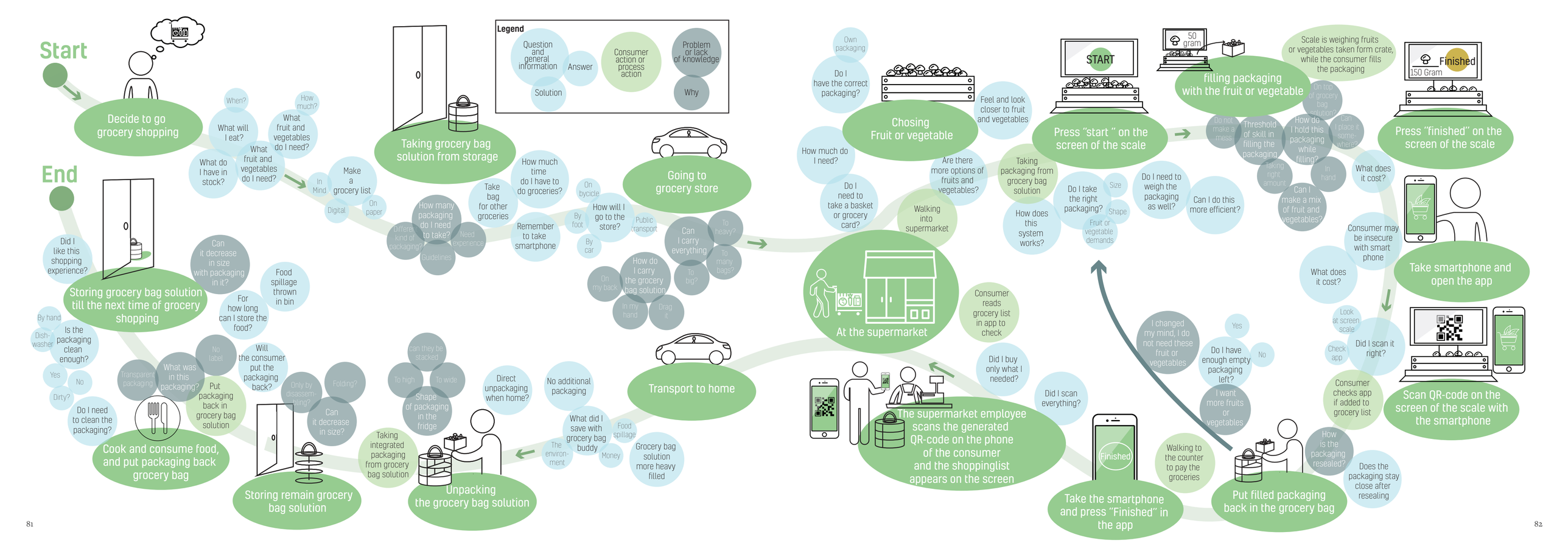
From lack of knowledge of packaging and sustainability, it was deducted that the consumer may have second thoughts, with using the smartphone and its features inside the supermarket, in the context for buying of fruits and vegetables.

In this project the functionality of the grocery bag buddy is more important than the shape of it, because the goal is to make a convenience reusable packaging solution, which is more sustainable than the current single packaging economy. This is stated, because the shape of the reusable packaging needs to be efficient and convenient inside the fridge, and in closets when storing.

The requirement is set that the packaging solution must be able to decrease in size, because the consumer has the threshold value with reusable packaging of limited storage space.

Transparency of the packaging could be convenient during storing of fruits and vegetables. This to see what is inside the packaging, because there are no labels on the packaging. The following wish is derived: The fruits and vegetables should be able to be seen through the reusable packaging.

To summarize, the "grocery bag buddy" can provoke multiple doubts and questions which need to be discovered during the actual use of the grocery bag buddy. The identified additional requirements and wishes are stated in chapter ''10.3 The Grocery bag buddy additional criteria". Through the customer journey, it was found that knowledge was missing from the vision that is supplemented in the embodiment of the "grocery bag buddy".


Start
Decide to go grocery shopping
When?
What will I eat?
How much?
What fruit and vegetables do I need?
What do I have in stock?
What fruit and vegetables do I need?
In Mind
Digital
Make a grocery list
On paper
Taking grocery bag solution from storage
Legend
Question and general information
Answer
Consumer action or process action
Problem or lack of knowledge
Solution
Why
How many packaging do I need to take?
Differe kind of packaging?
Need experience
Guidelines
Take bag for other groceries
How much time do I have to do groceries?
Remember to take smartphone
Going to grocery store
On bycicle
By foot
By car
How will I go to the store?
Public transport
Can I carry everything
To heavy?
To many bags?
To big?
How do I carry the grocery bag solution
On my back
In my hand
Drag it
Transport to home
Direct unpackaging when home?
No additional packaging
What did I save with grocery bag buddy
Food spillage
Money
The environ-ment
Grocery bag solution more heavy filled
Unpacking the grocery bag solution
Taking integrated packaging from grocery bag solution
can they be stacked
To high
To wide
Shape of packaging in the fridge
Storing remain grocery bag solution
Only by disassem-bling?
Folding?
Can it decrease in size?
Cook and consume food, and put packaging back grocery bag
Transparent packaging
What was in this packaging?
No label
Will the consumer put the packaging back?
Put packaging back in grocery bag solution
Do I need to clean the packaging?
Is the packaging clean enough?
By hand
Dish-washer
Yes
No
Dirty?
End
Storing grocery bag solution till the next time of grocery shopping
Did I like this shopping experience?
Can it decrease in size with packaging in it?
Food spillage thrown in bin
For how long can I store the food?
At the supermarket
Own packaging
Do I have the correct packaging?
How much do I need?
Do I need to take a basket or grocery card?
Chosing Fruit or vegetable
Feel and look closer to fruit and vegetables
Are there more options of fruits and vegetables?
Walking into supermarket
Consumer reads grocery list in app to check
Did I buy only what I needed?
Did I scan everything?
The supermarket employee scans the generated QR-code on the phone of the consumer and the shoppinglist appears on the screen
Take the smartphone and press "Finished" in the app
Finished
Walking to the counter to pay the groceries
Put filled packaging back in the grocery bag
How is the packaging resealed?
Does the packaging stay close after resealing
I changed my mind, I do not need these fruit or vegetables
Do I have enough empty packaging left?
Yes
No
I want more fruits or vegetables
Scan QR-code on the screen of the scale with the smartphone
Look at screen scale
Check app
Did I scan it right?
Consumer checks app if added to grocery list
Consumer may be insecure with smart phone
What does it cost?
Take smartphone and open the app
Press "finished" on the screen of the scale
Finished
150 Gram
Scale is weighing fruits or vegetables taken form crate, while the consumer fills the packaging
filling packaging with the fruit or vegetable
50 gram
On top of grocery bag solution?
Can place it somewhere?
How do I hold this packaging while filling?
In hand
What does it cost?
Can I make a mix of fruit and vegetables?
Do not make a mess
Threshold of skill in filling the packaging
Taking right amount
Press "start " on the screen of the scale
START
Taking packaging from grocery bag solution
How does this system works?
Do I take the right packaging?
Size
Shape
Fruit or vegetable demands
Do I need to weigh the packaging as well?
Can I do this more efficient?

10.3 The Grocery bag buddy additional criteria

The first criteria were set in chapter "9.2 criteria", which are based on the analysis phase, and not especially set-up for the grocery bag buddy. To define the design of the grocery bag buddy, additional requirements and wishes are stated. The additional requirements are deducted from the customer journey in chapter "10.2 Customer journey grocery bag buddy". The requirements are used to judge the design of the grocery bag buddy on in the next chapters. The requirements are ordered by category.

Additional requirements

1.Performance

1.11 The grocery bag solution must be able to be carried by one hand by the consumer.

1.12 The reusable packaging needs to be able to be held in one hand, while filling the packaging with fruits or vegetables.

1.13 The packaging solution must be able to decrease in size when storing of the packaging.

1.14 Each of the packaging must be able to be taken separately from the grocery bag solution

3. Shape, colour, finishing

3.2 The fruits and vegetables must be able to be seen through the reusable packaging.

8. Information system

8.2 The consumer must be able to return the fruits and vegetables, after it has been scanned by the consumer with the app on the smart phone.

Additional wishes

W1.9 The grocery bag solution should at least be able to carry eight packaging with the volume of a 900 liters. (Appendix VI A)

W1.10 The grocery bag should be able to be carried in multiple ways.

W1.11 The smart phone app should be simple in use and convenient, also for consumers less familiar with the smart phone.

10.4 Defining the shape and colour

Introduction

In this chapter, an analysis is done in used colours and shapes of sustainable and reusable products. These products are assumed to be recognised as sustainable products, and therefore used as reference in the design of the grocery bag buddy. From the collected sustainable and reusable products, a collage is made. From this collage a colour palette is made and a shape analysis performed.

Function over shape

In this project, the functionality of the grocery bag buddy is more important then the shape of it, this because the convenience and reuse are the main objectives of this project as set in the design goal in chapter "9.1 Design goal".

Sustainable products shapes analysis

On the next page, the sustainable products collage is presented (References of the images of the product collage can be found separately in the bibliography). From the collage, it can be deduced that most of the found sustainable products in the collage consist of a combination of two materials or two colours, from which the colour green is often used. The products in the collage were selected on their function, material and/ or appearance because the grocery bag buddy is wished to be functional, visual sustianable. The shapes have relatively large rounded edges in comparison with the products, also, the edges look soft. The cylindrical products have an organic curve going from wide to small. On top of the products, are indented shapes, in which either information is shown or is used as use-cue. With an indented shape a part of the product lays lower than the surface of the product is meant.

Sketches shape study

From the collage on the next page, the shapes in figure 41 were identified. These shapes are used as reference for grocery bag solution.

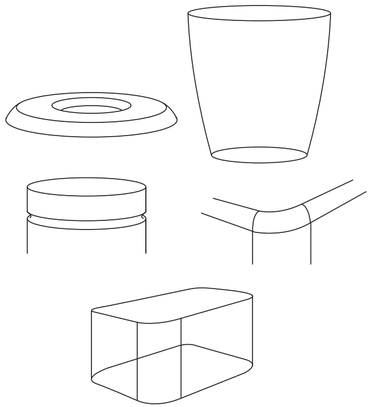


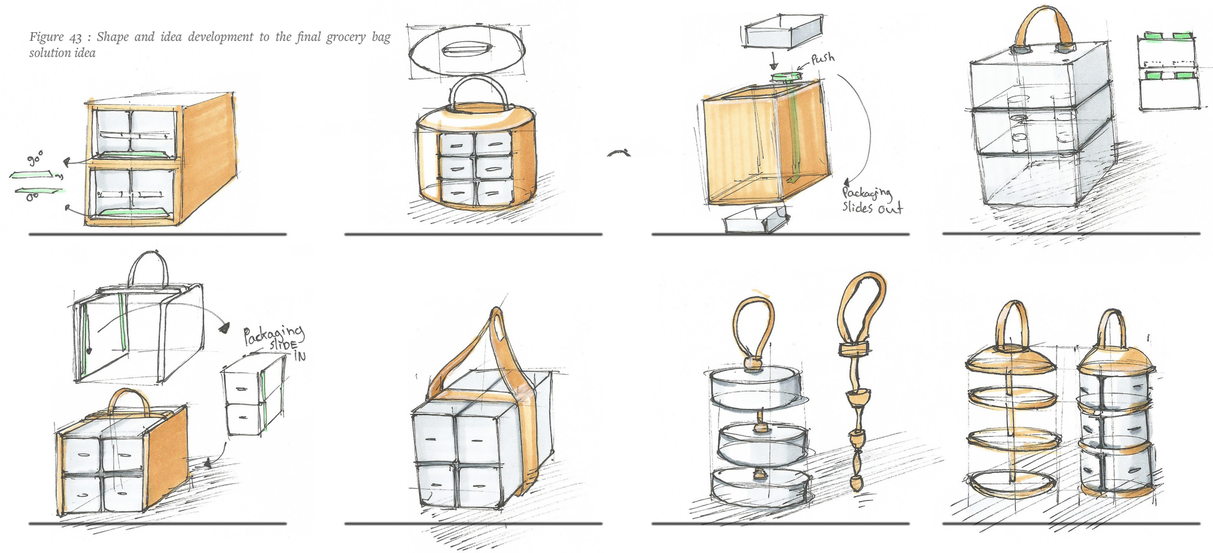
Figure 41 : Deducted shapes from sustainable product collage.

Used colours

To have a reference for used colours on sustainable products, a colour palette was identified from the sustainable products collage on the next page. In figure 42, the colour palette is illustrated. It can be seen that multiple green colours are used. The green colours are often used in combination with grey and or white, as shown in the collage on the next page.

Figure 42: Colour palette identified from the sustainable products collage.

Figure 43 : Shape and idea development to the final grocery bag solution idea

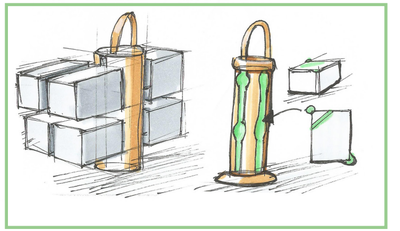


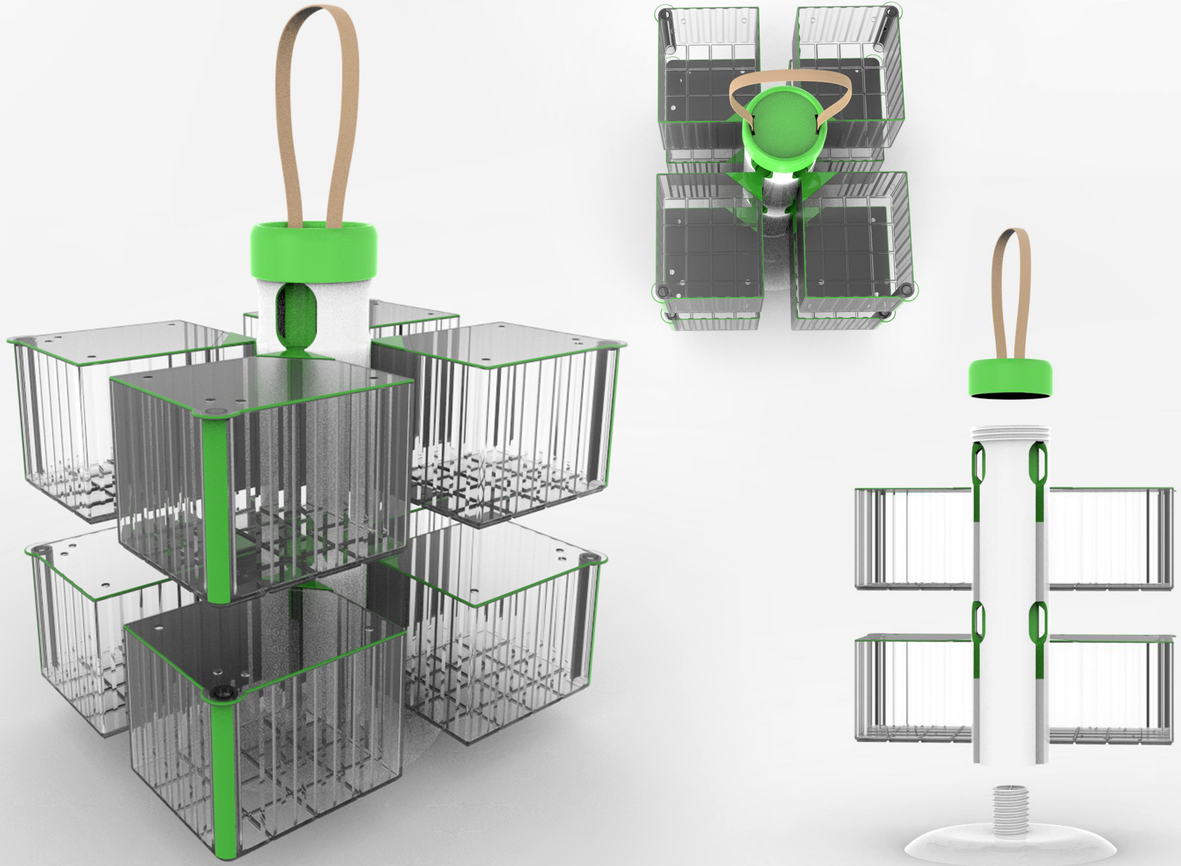
From shape analysis to the final grocery bag solution idea

Sketches are made of possible solutions for the grocery bag solution (figure 43). The sketches are put in chronological order, to show the development of the elaborate idea and the shape. The shape went from a functional and efficient box shape, to a combination of cylindrical and box shapes.

The ideas were judged on the criteria set in "10.3 The Grocery bag buddy additional criteria", and also by subjective insights in the potential of the ideas. The idea on the right in the green box, was chosen to be embodied further. This because of size and convenience. The packaging enables the consumer to take every packaging separate. Also, a relatively small object retains when the packaging are taken from it.

The shapes are cylindrical and separated in multiple parts. This to make the different features of the idea stand out. In the next chapters of the embodiment, the colour palette is used to give colours to use cues as to make the product look sustainable as pleasing. From now on the name of the elaborate idea is "the grocery tree".





10.5 The Grocery tree design

In this chapter, the embodiment of the grocery tree is explained by the following subjects: Features, Unique selling points, appearance, convenience, use cues and dimensions.

Features

The grocery tree consist of multiple features. One of the features is that it can be disassembled by either sliding or turning the parts. This to make maintenance convenient, and to be able to decrease the grocery tree in size (chapter "10.3 The Grocery bag buddy additional criteria"). Also, this makes an expendable part that can be screwed in between the foot and tree possible in the future as well. The parts can be replaced, or taken and be repaired. In figure 44, the grocery tree with all its parts is illustrated, to make clear what names are used for which parts.

The design of the packaging is based on the consumer research in reusable packaging, the identified thresholds and most important packaging features. This was done by asking questions directed on the mushroom packaging. In chapter "10,6 The grocery tree packaging", the packaging itself is explained in more detail.

The grocery tree is a grocery bag and packaging in one. For convenience and reference to a grocery bag, the decision for a flexible handle was made. A flexible handle is also convenient in storage, because it can be folded small.

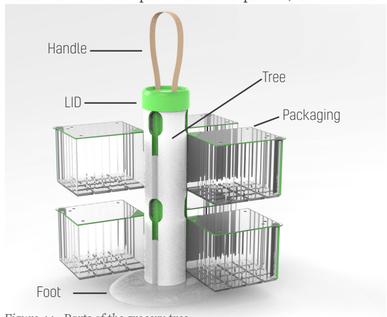


Figure 44 : Parts of the grocery tree

Unique selling points

The grocery tree is a new kind of product for the fruit and vegetable sector. The product brings the following unique selling points:

- A reusable packaging product, which is designed for packaging of unpackaged fruits and vegetables.
- Reusable packaging designed to support the consumer in fruit and vegetable shopping of unpackaged fruits and vegetables.
- The grocery tree is a packaging and grocery bag in one, designed to eliminate single use packaging.
- Multiple packaging sizes can be hanged in the tree. The consumer can buy different sizes depending on their needs (figure 56).

Convenience

The grocery tree enables the consumer to package unpackaged fruits and vegetables, at the supermarket. Each of the packagings can be taken from the tree separately, at every moment. The handle is made of a propylene webbing, which is flexible (10.7 Material choice"). The soft handle makes it possible to carry additional bags in one hand. If the strap is worn it can be replaced by removing the lid. The grocery tree can be carried by the flexible handle and can stand on its own on the floor, which is convenient when the consumer needs to have two free hands. The foot is an ellipse shape, and the packaging has a longer and shorter side. This to make the grocery tree more convenient when it is carried on the side of the body. A conventional grocery bag has the same orientation. In the next chapter, the convenience of the packaging is explained. Also, other size packaging are presented.

The grocery tree has slides in which the packaging are placed, this solution is designed for speed and simplicity in use. When all the packaging are removed from the grocery tree, it can be stored in separate parts if desired by the consumer.

Appearance
In the previous chapter "Defining the shape and colour", the overall shape and used colours were defined. From that chapter, a more detailed grocery tree was created. By developing detailed drawings into a 3D CAD model. The shape of the CAD model is partly defined by the dimensions and the optimization in the chapter "10.9 Optimising the design". The final design of the grocery tree is presented on page 87.

The shape of the grocery tree is based on the sustainable product collage in the chapter "10.4 Defining the shape and colour". The grocery tree has cylindrical shapes and box shapes with relatively large fillets. To make the product look strong and efficient the packaging are hanged inside the tree. To show the consumer that the tree consist of multiple parts, a lid is designed which sits like a lid from a jar over the tree. Also, the colour green is used to show that the lid is a separate part. The handle is flexible and coloured light brown, as a reference to natural materials. By only adding green colour to separate parts and certain features, a look of a simple in use product was aimed at. The used colours are based on the colour palette in figure 42. The foot was kept white as the tree, this to have a focus on the other features and parts of the grocery tree. If that part was coloured green as well, it becomes a visually busy product, which is less clear for the consumer. The appearance of the packaging is explained in more detail in chapter "10.6 The Grocery tree packaging".

Use-cues
A use-cue, is a feature that illustrates the consumer on how to use a product or part of a product. This can be done through colour, shape, light, sound and graphics. The grocery tree has use-cues, showed through shape and colour.

The lid has an oversized shape over the tree, which is a reference to a lid of a jar. The lid is made green, to emphasize that it is a separate part from the tree. The threat in the lid and on the tree, could be seen as a use-cue that the lid can be screwed on the tree. In figure 45, the lid on the tree is presented. In figure 46, the use cue of the threat on the tree is presented.

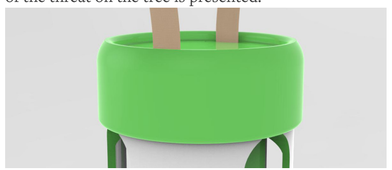


Figure 45 : Use-cue of shape and colour of the lid and tree.

The packaging are hanged inside the three, to guide the consumer on where and how to hang the packaging inside the tree, use-cues are used. A wider hole is made at the top part of the slide, which shows were to start with sliding the packaging inside the tree (figure 47). This hole is given a green colour to emphasize where the slide profiles are. The colour white of the three, the green holes and the slide profiles have a great contrast in colour to guide the consumer.

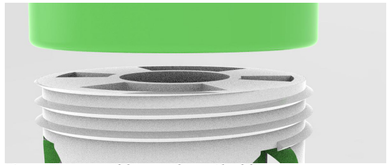


Figure 46 : Use-cue of threat on the outside of the tree.

The packaging has the same colour on the part that slides in the slide profiles (figure 48). Other packaging specific use-cues are explained in the chapter "10.6 The Grocery tree packaging".

Figure 47 : Use-cue of threat on the outside of the tree.

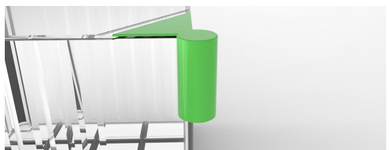


Figure 48: Use-cue packaging for slide profile.

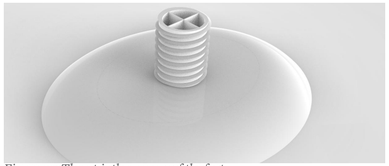


Figure 49: Threat is the use-cue of the foot

The foot of the grocery tree is connected with the tree, by a threat connection. The foot has an outer threat which can be seen as use-cue. It activates and informs the consumer on how to attach it to the grocery tree. In figure 49, the foot of the grocery tree is presented.

Dimensions
The dimensions of the grocery tree are partly depended on the packaging size. As reference the dimensions of the blue mushroom basket with lid were taken. The volume of the new packaging is 1080 cm3 and the mushroom packaging had a volume of 900 cm3. This increase in size is due to a different shape. According to DINED (2004), the hand height when standing for P1=660 mm and for p99=912 (figure 50). The overall height of the grocery tree is 448,74 mm, which includes the handle. The grocery tree can be carried by most persons from 20 - 60 years old (DINED, 2004). A conventional grocery bag without handle has a height of 455,0 mm. In figure 51, the dimensions of the grocery tree are illustrated. In figure 52, the packaging dimensions are illustrated. The grocery tree is smaller than a conventional grocery bag. This makes sense, because it is designed to carry only unpackaged fruits and vegetables.

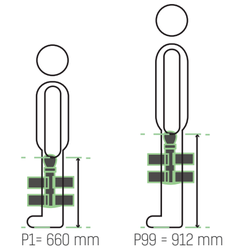


Figure 50: Hand height consumer P1 and P99, data retrieved from DINED (2004).

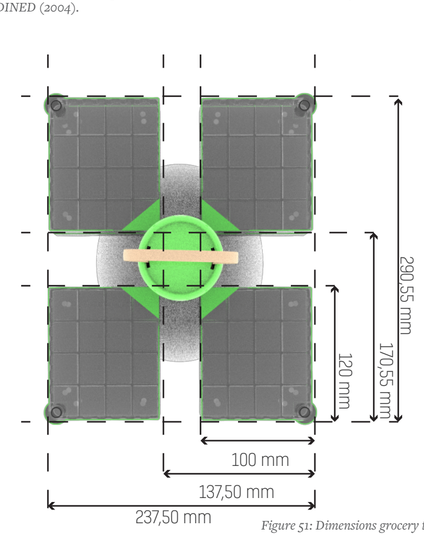


Figure 51: Dimensions grocery tree.

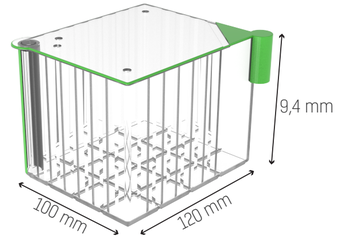
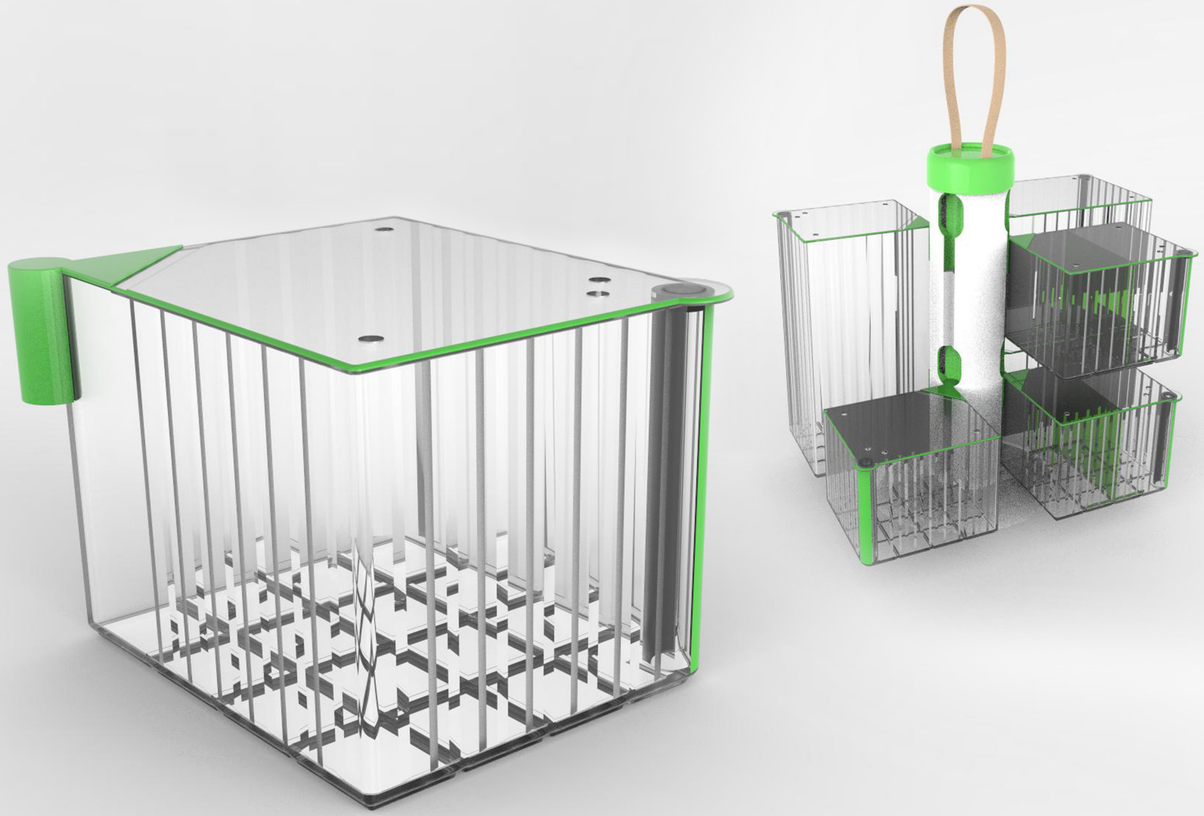


Figure 52: Dimensions packaging.



10.6 The Grocery tree packaging

The packaging of the grocery tree is explained in a separate chapter, because this project is based around packaging, and therefore an elaborated packaging design was performed. This chapter covers the following subjects concerning the grocery tree packaging: Features, unique selling points, convenience, appearance, and use-cues, holding the packaging.

Features
The packaging is designed to be reusable and to be part of the grocery tree. The packaging is based on the dimensions of the blue mushroom packaging, but because of the shape, a bigger volume was obtained.

In chapter "8. overview key findings", it was perceived that the lid of the packaging should be part of the basket. The hinge of the lid of this packaging is, therefore, part of the packaging and made of a relatively thin layer of PET as used in a grapes packaging, analyzed in the chapter "4.3 Packaging materials". A comparable product is the "Tupperware Smartclip" packaging, this product uses a flexible plastic hinge as well (Tupperware, n.d.). This product is a warranty of two years. It is set that the hinge of the grocery tree packaging should at least work for two years when opened and closed twelve times a week (In total round 1250 times). This number is calculated by if the consumer goes to the supermarket three times a week, and the packaging is opened and closed at the supermarket and at home twice, this is a rough estimation of the amount of times the hinge should work. On the other side of the packaging is a resealable connection. This connection is made of two bodies that are pushed into each other (figure 53). For this seal, the amount of time it should work is the same.

The bottom of the basket has a structure for moist and to protect the fruits and or vegetables. The bottom structure influences the cleaning time, but it saves the quality of fruits and vegetables. Also, the bottom structure adds strength to the packaging. The structures on the sides were added after the optimisation phase, in the chapter "10.9 Optimising the design". This structure reduced the weight of the packaging and added strength.

The holes in the lid of the packaging are to make the exchange of oxygen and carbon dioxide possible, which keeps the fruits and vegetables fresh for a longer period of time. These features were also found in the packaging of other fruits and vegetables (Table 4).

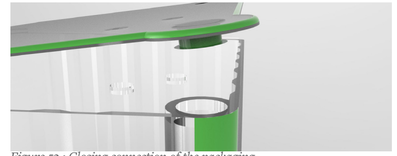


Figure 53 : Closing connection of the packaging.

Unique selling points
The unique selling points of the packaging are:

- A reusable packaging for at least 2 years.
- A resealable packaging.
- A packaging that opens diagonal.
- A packaging that is part of a kind of grocery bag
- A packaging with multiple use-cue instructions, that informs about the use of the packaging.
- Packaging with a flat lid, which is convenient in stacking in the fridge or closet.
- Packaging solution with multiple packaging sizes.
- A packaging with holding instructions.

convenience
The packaging is made to be convenient for the consumer. This is done by looking at; the threshold values of reusable packaging, the stages the packaging goes through and what the consumer desires from a packaging (chapter "8.0 Overview key findings"), (Chapter "10.2 Customer journey grocery bag buddy"), (chapter "10.3 The Grocery bag buddy additional criteria").

The packaging has a diagonal solid part, which is there to hold the packaging by during the filling process. In figure 54, the solid part is green, next to the green part is the hinge and behind that is the lid. In figure 60, the intended ways to hold the packaging while filling is illustrated.

At the end of the lid, an overhanging round part is shaped, this to have convenience in the opening of the lid. This shape is also designed as a use-cue to recognize where to open the packaging (figure 55).

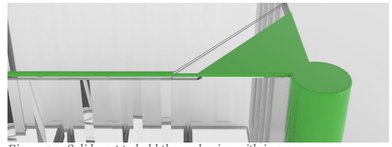


Figure 54 : Solid part to hold the packaging with in green.

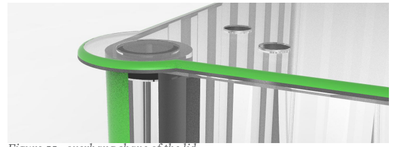


Figure 55 : overhang shape of the lid.

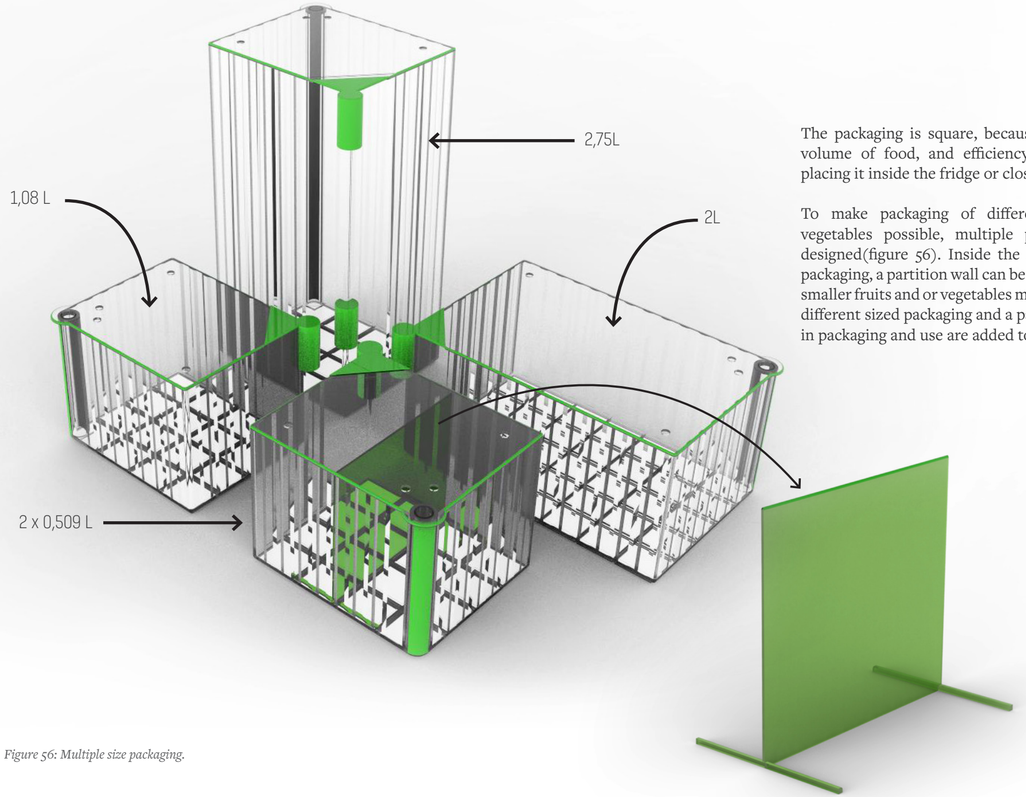


Figure 56: Multiple size packaging.

The packaging is square, because of efficiency in the volume of food, and efficiency and convenience in placing it inside the fridge or closet.

To make packaging of different sized fruits and vegetables possible, multiple packaging sizes were designed(figure 56). Inside the mushroom size based packaging, a partition wall can be placed, this to package smaller fruits and or vegetables more efficient. By having different sized packaging and a partition wall, flexibility in packaging and use are added to the grocery tree.

Appearance

The packaging is transparent with green elements. The transparency is to let the consumer be able to see the fruits and vegetables. It is also convenient when the packaging are in storage (10.3 The Grocery bag buddy additional criteria). The green elements are there to inform the consumer in the use of the packaging. The edge in figure 57, is made green and larger than the other edges for multiple reasons. It informs the consumer on which side is the outside of the packaging, because that edge is always on an outer corner of the grocery tree. The edge, also informs on where the closing connection of the lid connects. The connector part of the lid is made green as well (figure 58). The green colour is based on the colour palette of figure 42.

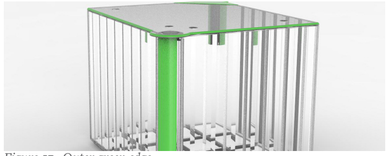


Figure 57 : Outer green edge.

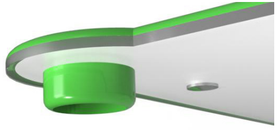


Figure 58 : Connector part lid

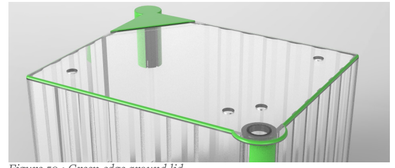


Figure 59 : Green edge around lid.

Use-cues

The packaging has multiple use-cues to inform the consumer, who according to chapter “8. Overview key findings” lacks knowledge about packaging and its features.

The lid has a green edge around it, to inform the consumer on where the lid is placed (figure 59).

The green colour of the outer edge and the connector part on the lid is already explained in the sub chapter “ appearance “.

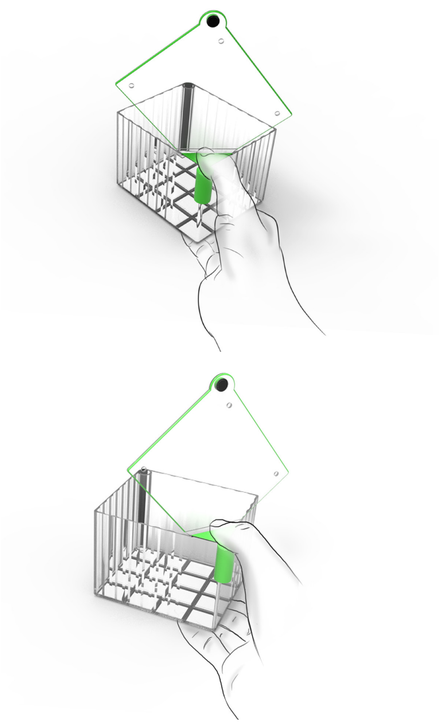
The solid triangle on top of the packaging informs the consumer on where to hold the packaging during filling (figure 54). In the sub chapter “holding the packaging”, the intended way of holding the packaging while the filling is explained.

The cylindrical body at the edge of the packaging informs the consumer on how to place the packaging in the grocery tree (figure 48).

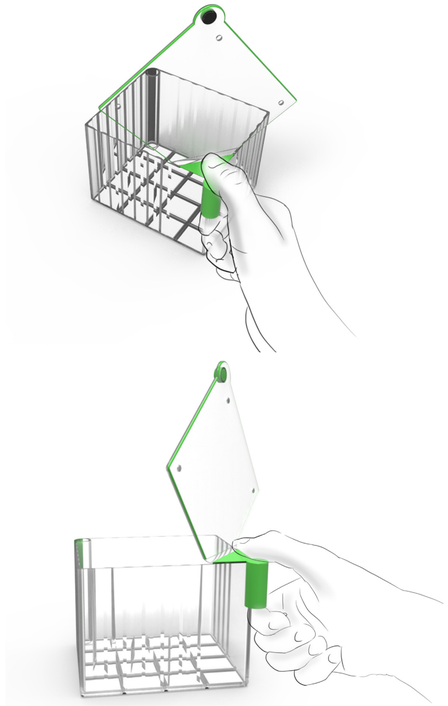
Holding the packaging

The packaging is designed to support the consumer in the filling of the packaging, to be clear and relatively simple in use. This is the reason why there is a colour contrast between the packaging and the use-cues. In this part, the intended way of holding the packaging while filling it is explained, as the opening and closing of the packaging.

The lid opens diagonal, this to have a big opening when the lid is up, and still have a space to put the thumb on top, to hold the packaging. The packaging can be held by the cylindrical shape at the corner or at the bottom of the packaging. Consumers may also hold the packaging by clamping the body horizontal in their hand. In figure 60, the two first-named holding positions are illustrated. The grocery tree is designed that the packaging needs to be taken from the tree before the lid of the packaging can be opened completely. It is not intended that the bottom packaging are filled when the packaging are inside the grocery tree, the upper packaging in the grocery can be opened while they are still hanging in the grocery tree, but they still need to be taken from the grocery tree to be weighed.



Position 1: thumb on top of the lid and the remaining fingers below the packaging.



Position 2: thumb on top of the lid and the remaining fingers below the cilindrical part.

Figure 60: Holding the packaging while filling.

10.7 Material choice

The material of the grocery bag tree and its packaging was determined by using multiple criteria. In chapter "4.3 Packaging materials", the materials of the current fruit and vegetable packaging were identified and analysed. The data of that chapter was used in combination with more specific material properties, to choose the material that suits the grocery tree and demands best. The material choice for the packaging, the tree with foot, and the handle are explained separately in this chapter.

Table 3, figure 61 and figure 62 were made and used in the decision process to choose the materials. The materials were analysed on:

- Yield strength
- Young's modulus (flexibility till non-returnable deformation)
- Weight
- Price
- Transparency

Why is chosen to use plastics

For the parts plastic materials were chosen, this because of an implementation plan that it could be made from recycled material. Also, because of the production speed and complexity of shapes that are possible with plastic molding. Transparency was also demanded as packaging property.

The packaging

Only one material is used in the packaging, this to make sorting of the packaging more efficient when disposing of it(Chapter "8. Overview key findings"). The packaging should have the strength to hold the groceries when hanged in the grocery bag tree. The packaging are on the outside of the grocery tree, which means they should be able to absorb impacts, for example during transport. The material should have a degree of flexibility, to absorb impacts without breaking or tearing. Cheaper packaging is more convenient for the consumer, especially if the consumer wants to buy more packaging or when the packaging tears after two years of usage. The fruits and vegetables should be visible through the packaging, which makes a relatively high level of transparency convenient. Polyethene terephthalate (PET) has according to table 3, a high level of transparency. According to figure 61, PET has a relatively high yield strength and relatively high Young's modulus, which makes it a strong material, but also flexible. These are ideal properties for packaging that should withstand impacts. PET is according to figure 62, the cheapest plastic material. PET is the material that fits the asked properties of the packaging best.

The tree and foot

The tree needs to be strong to hold the filled packaging. It is also preferred that the tree is more rigid than the packaging. The profiles in which the packaging slide and sit, need to be rigid because otherwise, it could be that the profiles deform because of the weight of the filled packaging. If the profiles deform, it would be difficult to slide the packaging out. Also, The grocery tree needs to be strong and rigid enough to hold the packaging, when they are only hanged on one side of the tree. In such situation, the grocery tree needs to be rigid to deform as little as possible. The packaging tree and foot are wished to be as light as possible, for convenience for the consumer. Because of the amount of material needed in the tree and foot, a relatively cheap material is demanded to keep costs low. No transparency is wished for these parts. Polypropylene (PP) and high-density polyethylene (HDPE) are both found efficient for the demanded properties. A side note, these materials are transparent without additive, which means for the grocery tree to be white or green, additives need to be added to the plastic mixture. Adding an additive influence the purity of the material. Painting of the plastic would be another option. According to figure 61, both materials have relatively low flexibility in comparison to other materials and average yield strength. From figure 62, it was deducted that polypropylene is lighter than high-density polyethylene. The materials have comparable prices. From the analysis is concluded that polypropylene is more light and therefore chosen as the material for the tree and the foot of the grocery bag tree.

Handle of the grocery bag tree

The handle of the packaging is designed to be flexible and lightweight. The chosen material is a polypropylene webbing strap. A webbing of polypropylene can have different properties which are dependant on the material and the webbing. The polypropylene webbing taken as reference in this project is 2,5 cm wide and has a minimum breaking point at a weight of 136 kg (1.334 Newton), (Strapworks.com, n.d.). In figure 62, it can be perceived that polypropylene is a relatively light plastic, and therefore ideal for a lightweight webbing strap.

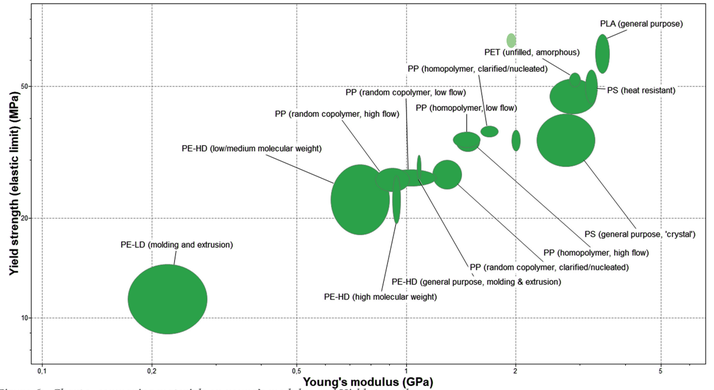


Figure 61: Chart 1, comparing materials on young's modulus and Yield strength.

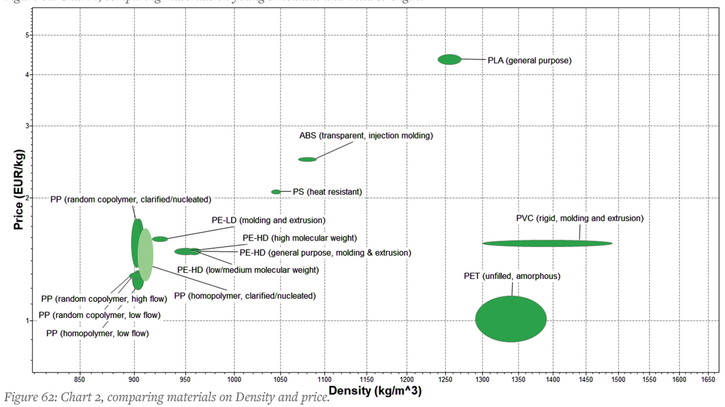


Figure 62: Chart 2, comparing materials on Density and price.

10.8 Performance under stress

To test the design of the grocery tree, a static simulation was performed in Solidworks (SolidWorks, 2018). This is done to analyse how it performs when forces are applied to it. The data from this analysis can be used to make optimisations to the concept. In this chapter, each part of the grocery tree is analysed separately. Per part, the following is performed and analysed: Pressure applied to the part, analysis simulation, conclusion, and recommendation to optimise the part(in green).

Safety

To have a safety measure for the amount of weight the grocery tree needs to be able to carry, a weight of 250 grams of mushrooms was multiplied by four. This also, because the packaging must be reusable, it needs to be stronger and more impact-proof than single-use packaging.

The handle

The handle is held by the consumer and wraps around the inner part of the lid. The handle itself according to the SolidWorks model will weigh 3.4 g. The handle needs to carry the grocery tree (2.6 kg) and 8 kg of fruits and vegetables. This makes a total of 10.6 kg of weight, which is a force on the handle of 104 N. No polypropylene webbing strap was available in SolidWorks, but according to the properties of the strap in the chapter "10.7 Material choice", the strap can take 1334 N. This is more than 10 times as much pressure. The strap is more than suited to carry the weight of the grocery tree in use, if the connection of the strap is as well needs to be tested with a prototype.

The lid

The lid carries the weight of the grocery tree parts below, which have a combined weight with fruits and vegetables of 10.6 kg. The lid itself weighs 40.7 g. The lid has pressure from the weight of the packaging via the strap and the weight of the filled grocery tree on the thread. In table 6, the properties of polypropylene and Polyethylene terephthalate are presented.

In figure 60, the stress on the lid from the strap is simulated. The maximum measured stress is 4.0 MPa, which according to table 4 is far from the yield strength. The maximum measured strain was 0,1 per cent. The threat had lower pressures and strains than the inner part of the lid.

The conclusion is made that the part is over defined. The thickness of the inner part of the lid could be made thinner. Ribs could be used on the underside for extra strength. The side walls of the lid can be made thinner as well, without having to use ribs.

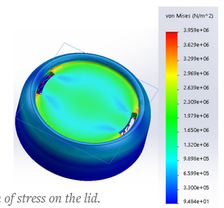


Figure 63: Simulation of stress on the lid.

Table 6 : Properties of polypropylene and polyethylene terephthalate, data retrieved from CES EduPack (2019).

	Yield strength (MPa)	Young's modulus (GPa)	Strain (% of original length)
Polypropylene (PP)	31,9 - 36,4	1,37 - 1,58	52,1 - 232
Polyethylene terephthalate (PET)	50 - 55	2,8 - 3	280 - 320

The tree

The tree has forces on the thread of the top part, the bottom part, and forces of the filled packaging hanging from it. The reaction of the tree on the forces is analysed in this part of the report. The tree weighs 805.5 g and has 8 kg of fruits and vegetables and 1.7 kg of packaging hanging of it. The forces are put vertically on the tree, which is partly different from the realistic situation, in which the packaging create horizontal forces as well. This is not simulated because of the limitations of the computer model in the available time. It is assumed, that the vertical force has more influence on the design of the model. When all packaging are hanged on the tree with the same weight, there is more compression on the tree then torsion. When an uneven number of packaging are hanged from the tree torsion takes place. The reaction of the tree on these forces need to be analysed in further tests. Figure 61 presents the stress on the tree. The maximum measured stress 0.1 MPa. The maximum measured displacement was 3.0×10^{-4} mm.

It is concluded, that the tree can be optimised in cost and material use

This can be done by making thinner wall thickness and designing a more efficient extrusion profile. This could also benefit the weight of the tree, for consumer convenience.

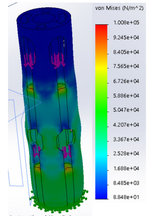


Figure 64: stress on the tree when a pressure of 94.9 Newton in it.

The foot

The foot has a vertical force on top of it when it stands on the ground. The weight of the grocery tree on top of the foot is 2 kg, the foot itself weights 72.9 g. The foot was optimised before the analysis by adding a rib structure on the bottom. The total force with fruits and vegetables on top of the foot is 103.3 N (The force is applied to the thread on top of the foot).

In figure 65, a stress simulation on the foot is presented. The maximum measured stress is 1.8 MPa, which according to table 6, is almost 18 times lower than the yield strength of polypropylene. The measured strain was 0,056 per cent.

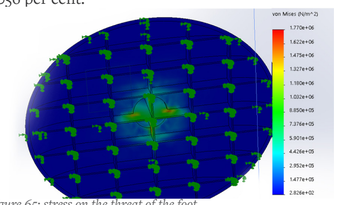


Figure 65: stress on the threat of the foot.

From the simulation can be concluded that the foot is strong enough to carry the grocery tree including fruits and vegetables. Weight and material could be saved, by optimising the foot.
The foot can be optimized by a thinner wall thickness of the foot itself and less ribs. On the edges less ribs are needed, because little stress is applied in that area.

The packaging
The packaging is hanged from one solid shape at the edge of the packaging. Vertical as horizontal forces are applied to this cylindrical part. Also, the packaging itself leans against the tree when it hangs. In this analysis, the fixture to the tree is only the cylindrical part. The packaging is analysed with and without the lid. The packaging weighs 209.5 g, and each packaging has 1 kg of fruits or vegetables inside it.

In figure 66, the stress simulation of the packaging without lid is presented, and figure 67 shows the displacement. The maximum measured stress is 4.1 MPa, which is more than 12 times as small as the yield strength of polyethylene terephthalate. The packaging is made stronger because of impacts during transport. The measured displacement is 0.7 mm on the outer side of the packaging. The solid cylindrical shape has minimal displacement, which is beneficial for sliding it in and out the grocery tree. The packaging could be strengthened by a structure on the sides, which saves material by smaller wall thickness.
The packaging with the lid is more rigid. This can be seen in the simulations (Figure 68). The maximum

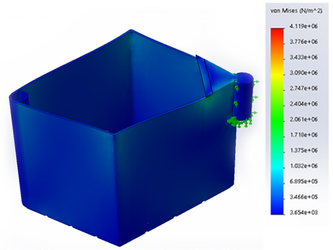


Figure 66: stress on the packaging without lid.

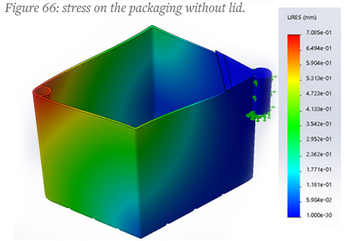


Figure 67: Displacement packaging without lid.

stress measured is 1.5 MPa. The measured displacement is also lower, $7.5x10^{-3}$ mm.

From this analysis it can be concluded that the packaging is strong enough to hold 1 kg of fruits or vegetables. It is assumed from this data that the packaging can also take an impact.

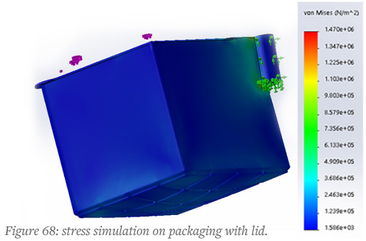


Figure 68: stress simulation on packaging with lid.

To optimize the packaging a structure on the sides of the packaging can be added. By adding a structure the wall thickness can be lowered. With this configuration the wall thickness of 1 mm can be made smaller as well. Which saves costs and material use.

Conclusion
The grocery tree is strong enough to contain one kg of fruits and or vegetables in each of the eight packaging. The design is over defined for its purpose. Each of the parts can be optimised to save material and weight. Lowering the weight of the grocery tree benefits the convenience for the consumer.

10.9 Optimising the design

The recommendation from the previous chapter (10.8 Performance under stress) are applied to the different parts. This is done to save material, weight and costs. In this project one optimisation step is performed. Each part is optimised and noted separately.

The lid

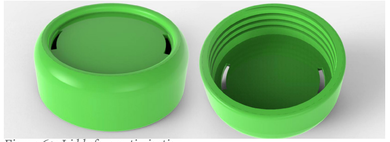


Figure 69: Lid before optimisation.

In figure 69, the first version of the bottom of the lid is presented. The lid was optimised by making the thickness of the inner structure thinner, from 2 mm to 1 mm. To strengthen the inner structure, 6 ribs were added to the bottom part. The wall thickness of the sides of the lid were made thinner, from 5 mm to 3 mm. In figure 70, the optimised lid is presented. The weight of the lid is reduced from 40.7 g to 25.2 g.

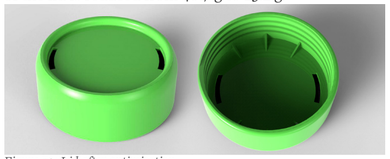


Figure 70: Lid after optimisation.

The tree

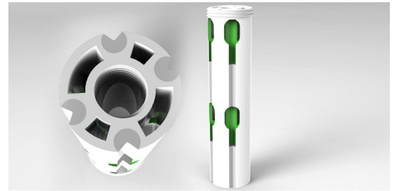


Figure 71: grocery tree before optimisation.

In figure 71, the tree before optimising is presented. In this project, only the holes through the whole tree were made larger. The recommendation of efficient extrusion design for the tree remains a recommendation, due to time limitations of the project. The wall thickness of the outer wall was reduced from 5 mm to 3 mm, and the wall thickness of the inner structure was reduced from 5 to 3 mm. Also, the tubes onto which the packaging slide, were extruded with a wall thickness of 1 mm. Figure 72 shows the optimised tree. The tree is reduced in weight from 805.3 g to 631.2 g.

Figure 72:Tree after optimisation.

The foot

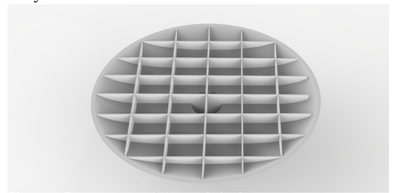


Figure 73: Foot grocery tree before optimisation.

To optimize the foot of the grocery tree, the ribs were rearranged (Figure 73). The ribs on the sides were removed, and the wall thickness of the ribs was made smaller from 1 mm to 0,5 mm. The weight of the food is reduced from 72.9 g to 58.1 g. The optimised food is presented in figure 74.

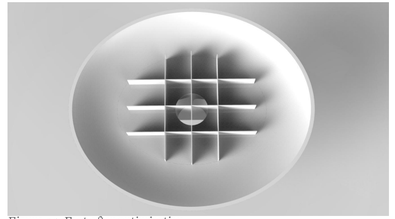


Figure 74: Foot after optimisation.

The packaging

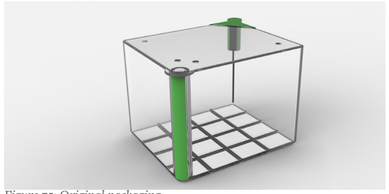


Figure 75: Original packaging.

According to the recommendation from chapter "10.8 Performance under stress", the packaging can be optimised by a strengthening structure in de side walls. Because of this structure the wall thickness can be made smaller. The packaging was optimised by cutting a structure from the walls, the walls thickness now varies between 1 and 2 mm. The non optimised packaging is presented in figure 75, and the optimised packaging is presented in figure 76. The weight is reduced from 209.5 g to 185.6 g.

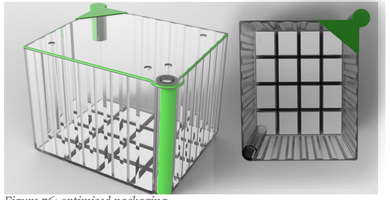


Figure 76: optimised packaging

Discussion optimisation

The parts are optimised to make them more sufficient. The next step is another performance analysis under forces, to see whether or not the optimisation has obtained the wished results. This second stress analysis is not done in this project, due to limited time. The prediction is made that the parts can still take the forces applied to them in use and in a safety situation, with 8 kg of fruits and or vegetables in the grocery tree packaging. This prediction is based on the relatively large difference in material limits, and data retrieved from the performance under stress analysis in the chapter "10.8 Performance under stress". In a second stress analysis, the reactions of the grocery tree when it is picked up should be analysed as well. The final design of the grocery tree in the chapter "10.5 The Grocery tree design" is based on this optimisation of the grocery tree parts.

10.10 Cost price

To have an idea about the cost of the grocery tree a rough estimation was done. This is done using the rule of thumb stated by Boeijen, Daalhuizen, Zijlstra, & Van der Schoor (2014). The rule states that the consumers price is seven to eight times the material costs.

The weight of the packaging is 185.6 g and the price of PET is 1.15 Euro per kg (CES EduPack, 2018).
Consumer price packaging:
8 x 0.1856 x 1.15 = 1.71 Euro

The total weight of the lid, the tree and the foot is 714.6 g and the price of PP is 1.33 Euro per kg (CES EduPack, 2018).
Consumer price grocery tree without packaging:
8 x 0.7146 x 1.33 = 7.60 Euro

The handle
It is assumed that around 50 cm of band is needed per handle. The price of one meter of PP webbing band is 0.35 Euro (Rijstextiles, n.d.). The consumer's price for the handle is:
8 x (0.35 x 0.50) = 1.40 Euro

If the grocery is filled with 8 packaging the consumer price would be 22.68 Euro.

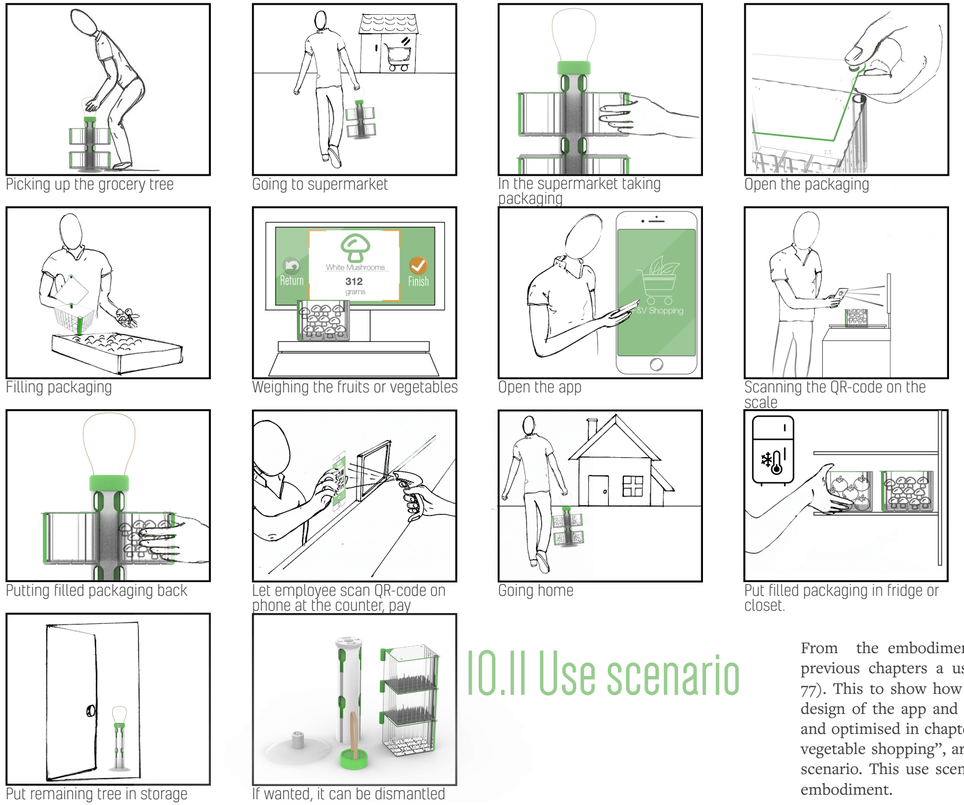


Figure 77: Use scenario of the grocery tree with the final design of the app and scale.

10.11 Use scenario

From the embodiment of the grocery tree in the previous chapters a use scenario was made (Figure 77). This to show how the product is used. The final design of the app and the scale, which are embodied and optimised in chapter "11. Digital support fruit and vegetable shopping", are already presented in this use scenario. This use scenario summarizes the complete embodiment.

F&V Shopping

11. Digital support fruit and vegetable shopping

In this part of the report the app and the scale interface which support the consumer inside the supermarket are presented. The app eliminates bar code stickers and involves the consumer more with fruits and vegetables, by giving the possibility to read more information about that fruit or vegetable. The app works in combination with multiple supermarkets. In the next chapters, the journey inside the app during grocery shopping is illustrated. From the journey the different screens of the app are designed and the thoughts behind the appearance of the app explained. The idea of the scale is discussed and optimised to make a more feasible elaborate idea for the weighing moment of fruits and vegetables in combination of this packaging.

11.1 Journey of the consumer inside the app and scale

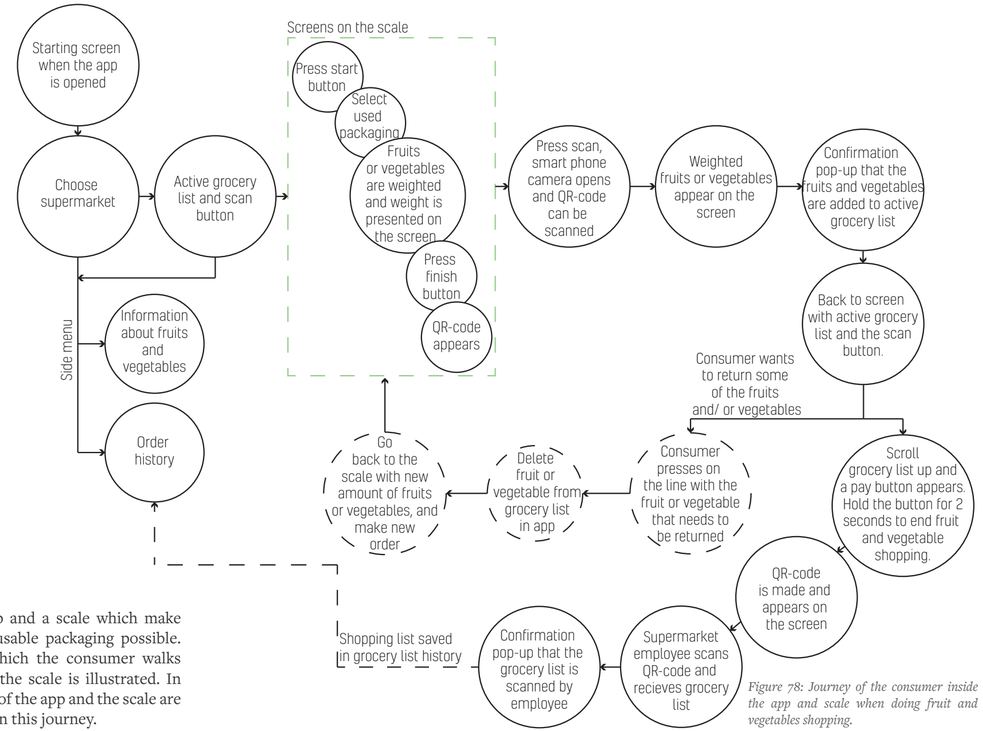


Figure 78: Journey of the consumer inside the app and scale when doing fruit and vegetables shopping.

The grocery tree has an app and a scale which make grocery shopping with a reusable packaging possible. In figure 78, the journey which the consumer walks through inside the app and the scale is illustrated. In the next chapter, the screens of the app and the scale are embodied, which are based on this journey.

II.2 Screens of the app

In this chapter, the screens of the app are presented. The screens are a mock-up of how the app may look like to the consumer. The design behind the screens are explained and the screens are presented in order of the journey illustrated in chapter "11.1 Journey of the consumer inside the app". The app is also discussed by comparing it another grocery shop app, this to gather insights in the quality of the designed mock-up.

Appearance of the app

To let the app show comparisons with the grocery tree, it was designed from the sustainable product collage (chapter"10.4 Defining the shape and colour"). The app contains rounded corners and 3D shapes. The colours, except the orange and red colour was deducted from the sustainable product collage. To support the consumer in grocery shopping with reusable packaging, a low-key app, which is approachable for consumers from different ages and smart-phone skill level was designed. This was done by relatively large letters and numbers, and by the use of colours for use-cues, for example, the scan button is made orange to make it stand out and to inform the consumer that to start scanning, the orange button needs to be pushed. The red colour stands for deleting an order and to end the grocery shopping list.
The screens of the app are presented in figure 74.
Now this app is designed for unpackaged fruits and vegetables, but it could be adapted to work with multiple kinds of products inside the supermarket.

Discussing the app

To discuss the designed mock-up of the app, it is compared with the AH app, which was identified on the timeline in chapter "7.1 Developments". The AH app is a platform on which food can be ordered online. The fruit and vegetable shopping app above is designed to work in the supermarket with the scales, not to work as a webshop app. However, by comparing it with the AH app, insights are retrieved. The AH app has more features, and the buttons of the features are smaller as is the text. The fruit and vegetable app has fewer options and therefore looks more simple, also because of the bigger buttons and text. The information about every fruit and vegetable is presented when you press a fruit or vegetable, you can also order from that screen. Having the information about the fruit or vegetable before you order activates you to read it. However, inside the supermarket, you may not want to have all the information about that food product on your screen every time you order. An advantage of the app above is that more clear confirmation is given after something is scanned or ordered. In the app above abstract figures of the fruits and vegetables are used, it can be discussed if real images of fruits and vegetables are more clear to the consumer (as used in the AH app). This could be researched by a user test.

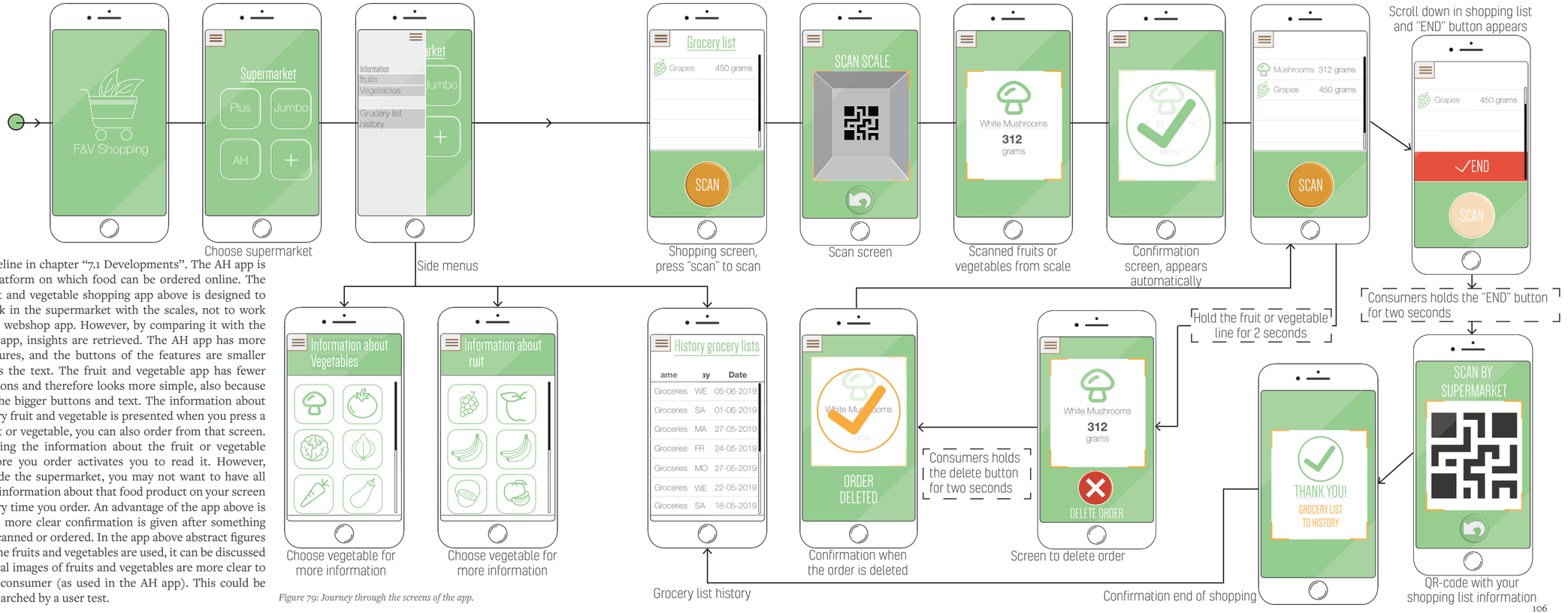


Figure 79: Journey through the screens of the app.

11.3 The original scale idea

The weighing moment of the fruits and vegetables is depended on the scale. In chapter "10.2 Consumer journey grocery bag buddy", the original idea for the scale was explained. In this chapter, the original idea is analysed and optimised to an idea that could be implemented more quickly.

Visionary scale idea

The original idea consists of a scale under every crate of fruits and vegetables. The scale measures the number of fruits and vegetables taken from the crate by measuring the difference in weight of the crate. In figure 80, the idea for a new method of weighing fruits and vegetables in the supermarket is illustrated. By having a scale under every crate the shopping experience becomes more convenient for the consumer because they need to walk less for filling, packaging, and measuring of one kind of fruit or vegetable. The result of all these processes at the same place (at the crate) is a more structured shopping pad that consumers walk inside the supermarket. The processes in total take less time because the consumer does not need to walk back and forward to a centrally placed scale. The combination of the app with the scale creates a new packaging experience that saves stickers and packaging materials. As it makes the consumer more aware of the amount of food they take, because they can see the weight of the taken food directly in front of them on a screen.

However, a scale under every crate of fruits and vegetables is a large investment compared to the current situation, in which two or more central scales are used.

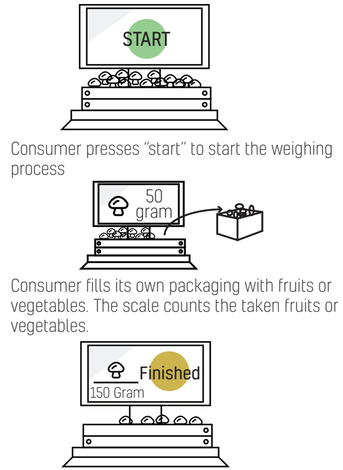


Figure 80: Potential new fruits and vegetables weighing idea.

The feasibility of a scale that measures the difference in weight being used at a supermarket, is not possible at the moment. In research by Meulendijks (2016), it was found that scales that measure the complete product are more conventional than scales that measure the loss of weight. To make a scale approved for usage at the supermarket, multiple criteria set by the "Nederlands Meetinstituut" (NMi) need to be met. In this report, the specific accuracy criteria are not discussed, because no prototype is made of the scale and the complete grocery tree. If a filled crate is measured, the scale needs to be able to carry the crate as measure it precisely upfront as when food is taken out, this asks for a special scale which is more expensive because of the load cells that are needed to deal with the weight on top of the scale. The weight of a full crate of mushrooms is around three kilograms, according to Champoord B.V. (n.d.). The difference in weight when the consumer fills the packaging needs to be weighted without additional pressure on the scale (Meulendijks, 2016). This implements that a system needs to be invented to inform the consumer not to lean on the crate and/ or scale when taking fruits or vegetables. Also, a safety feature to prevent overloading the scale need to be integrated. If the scale is overloaded a new calibration must take place (Meulendijks, 2016). In a personal conversation with Prof. dr. Balkenende, it was discussed to implement parts of the scale idea into a scale that is already in use. This to make the grocery tree with the app and scale easier to implement in a current supermarket. Also, the currently used weighing method is proven and approved by the NMi accuracy standards.

11.4 The optimised scale

In this project, materials of single-use packaging are saved by making a reusable packaging solution, this contradicts the investment of needing 20 or more times as many scales in the supermarket. It makes more sense to save material by using one or two centrally placed scales. Also, a lower threshold in using a reusable packaging for consumers could be achieved, by using a familiar scale principle. According to chapter "8.0 Overview key findings", the context at the supermarket should be adapted to fit reusable packaging, which can also be achieved by a centrally placed scale that weighs reusable packaging filled by the consumer.

To conclude, using a conventional centrally placed scale is more feasible and sustainable than having a scale under every crate of fruits or vegetables. The idea of the interactive app and scale are implemented in a centrally placed scale that measures a filled packaging, instead of weight differences.

The new scale concept is based on elements from the orginal scale idea in the previous chapter. In this chapter, the optimised idea is explained, the advantages of this idea explained, the technology that connects it with the app, and the screens of the scale illustrated.

The new scale is based on a conventional scale mechanism, in which the packaging filled with fruits or vegetables is weighted. The scale is placed at a central place in the fruit and vegetable section of the supermarket. The scale replaced the use of bar code stickers, by using QR-code technology. The QR-code created by the scale at the end of the weighing process can be scanned by the smart phone with the app. In chapter "11.1 Journey of the consumer inside the app", the journey of the consumer with the screens of the scale is illustrated.

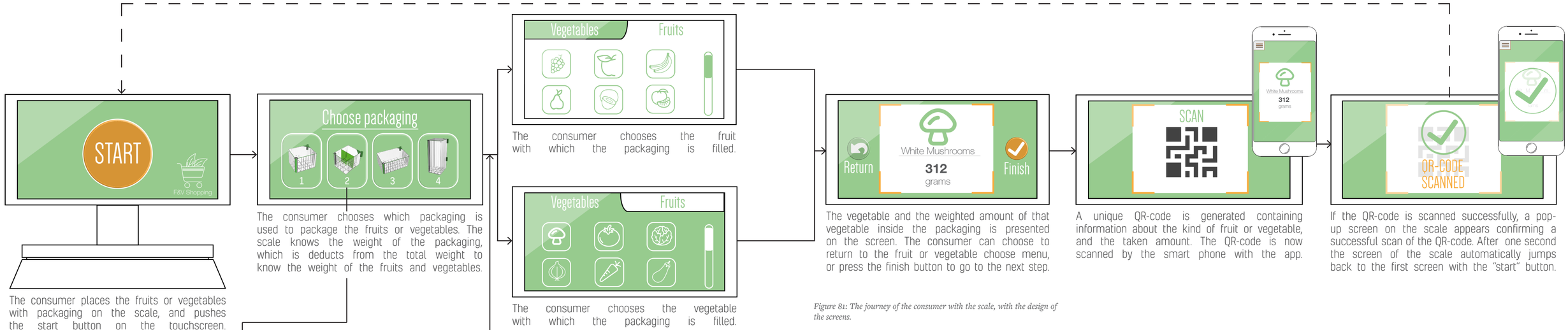
Appearance of the scale screens

The appearance of the screens of the scale are designed with the sustainable product collage as reference (chapter"10.4 Defining the shape and colour"). This to show the consumers that the app and the screens of the scale show comparisons. By connecting the appearances, the consumer may see the connection between the two and could be more easily convinced of their working. The screens of the scale should be low key and clear to consumers from multiple ages. In figure 81, the journey of the consumer with the scale is presented as are the designed screens of the scale. Below every screen is an explanation of the actions of the consumer and an explanation of what the screen consists of.

Technology

Embedded in the app and scale is QR-code technology. This technology was chosen because it can contain information and can be decrypted more quickly than a conventional bar code (Vazquez-Briseno et al., 2012). This technology does not use radio waves to store and retrieve data like RFID and NFC technology. The QR-code can be scanned by a smart phone camera, which decodes it and retrieves its content from a remote server (Vazquez-Briseno et al., 2012). Qr-codes can easily be generated (Vazquez-Briseno et al., 2012).

The technology inside the scale is not further developed in this report, because an existing scale is used. To make this idea of the scale reality, software needs to be written that supports the idea.



The consumer places the fruits or vegetables with packaging on the scale, and pushes the start button on the touchscreen.

The consumer chooses which packaging is used to package the fruits or vegetables. The scale knows the weight of the packaging, which is deducts from the total weight to know the weight of the fruits and vegetables.

The consumer chooses the fruit with which the packaging is filled.

The consumer chooses the vegetable with which the packaging is filled.

The vegetable and the weighted amount of that vegetable inside the packaging is presented on the screen. The consumer can choose to return to the fruit or vegetable choose menu, or press the finish button to go to the next step.

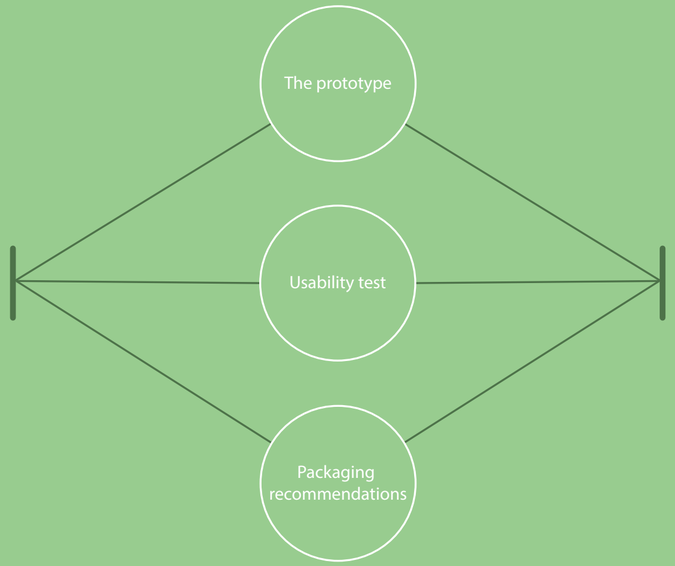
A unique QR-code is generated containing information about the kind of fruit or vegetable, and the taken amount. The QR-code is now scanned by the smart phone with the app.

If the QR-code is scanned successfully, a pop-up screen on the scale appears confirming a successful scan of the QR-code. After one second the screen of the scale automatically jumps back to the first screen with the "start" button.

If the consumer used the partition in the packaging, it could be that the packaging is already half-filled with fruits or vegetables. The consumer now chooses between "empty" and "half-full".

when the consumer chooses half full the scale asks for the weight of the previous weighted fruits or inside the packaging. When the weight is typed on the screen, the consumer presses enter.

Figure 81: The journey of the consumer with the scale, with the design of the screens.



03| Simulation

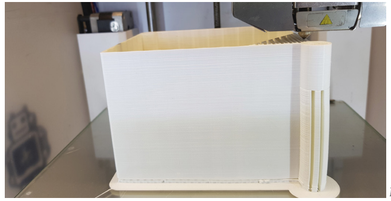
12. Testing

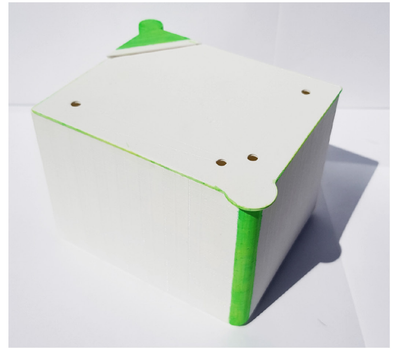
12.1 The prototype

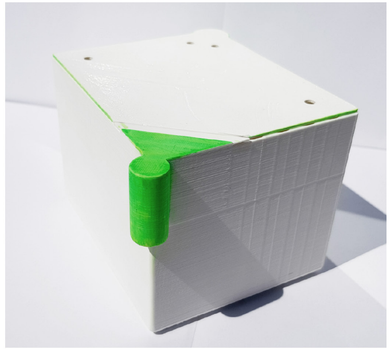
To test the convenience of the packaging, the size and shape of the packaging were made to match the CAD model. The coloured use-cues are copied onto the prototype as well (figure 82). The prototype is made with 3D printing (figure 83). The prototype is made to test convenience, which is why it has limitations on other areas.

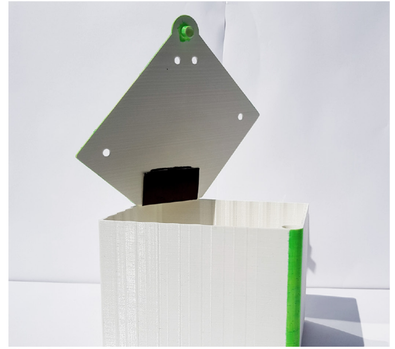
The prototype has the following limitation:

- Strength, the prototype is made from (PolyLactic Acid), and with a different production method, which is why the strength and flexibility properties are different than the original design.
- The prototype is not transparent, which could influence the judgement on convenience. Transparent packaging were found more convenient, because the consumer could then see the contents of the packaging (Chapter "8. Overview key findings").









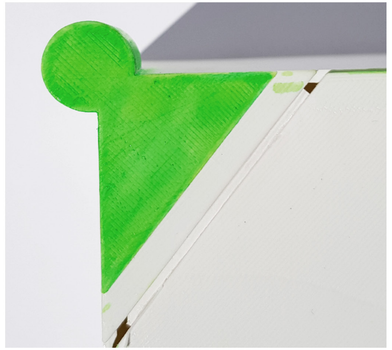


Figure 82: Taken pictures of the prototype packaging

Figure 83: 3D printing prototype.

12.2 Usability test

To see whether the concept packaging is perceived by the consumer as intended, it is tested in an usability test. The main purpose of the test is to observe the convenience of the packaging. The test is set up to retrieve insights into the ability of the packaging to support the consumer during grocery shopping of unpackaged fruits and vegetables. One of the thresholds of reusable packaging is the skill in filling of the packaging (chapter "8.0 Overview key findings). Another important key finding from the analysis phase was the lack of knowledge in packaging features. In this usability test, the convenience in the use of the packaging and the perception of the packaging features are tested.

Research questions
The following main research question is researched with this test:

- How does the consumer perceive the convenience of the packaging during filling it with fruits or vegetables?
    A. Is the packaging hold as intended?
    B. What use-cues are recognised by the consumer?

Method
A product usability evaluation is conducted in combination with an adjusted observational research (Van Boeijen, Daalhuizen, Zijlstra, & Van der Schoor, 2014). The actions and interactions of the participants with the packaging during grabbing, opening, filling and closing of the packaging are observed and described.

Stimuli
At the beginning of the test, the participants are shown a picture of the packaging hanging in the grocery tree (Figure 84). Also, the participants of the test are given a 3D printed real size model of the packaging (Chapter "12.1 The prototype).

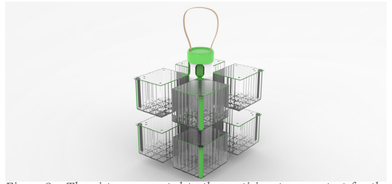


Figure 84; The picture presented to the participants as context for the packaging shape.

Participants
The test is conducted with 5 consumers (n=5). The participants have ages from 24 to 55 years old. The participants were students from the Technical University in Delft and consumers living in Dordrecht.

Procedure
The test consist of two parts. The first part is a usability test, in which the participants are asked to take the packaging from a box of 30 cm high, then fill the packaging half full with mushrooms and at last close the packaging before putting it back on top of the box. The participants are asked to think out loud when performing the test. Before the test, the participants are explained that the packaging is designed to be reusable by the consumer and is designed to package unpackaged fruits and vegetables. At this moment, the picture of the packaging hanging in the grocery tree is showed to the participants. This is done to give the participants context on the shape and use of the packaging.

The second part of the test, the interview. The participants were asked the following questions:

1. Why did you hold the packaging like you did?
2. Do you think it is convenient to hold the packaging at the green cylindrical part, at the corner of the packaging?
3. Why do you think the green colours are used on the packaging?
4. Do you think it is a convenient reusable packaging? And why?

Equipment
To conduct the research to following objects were used.

- A box to place the prototype on (this resembled taking the packaging from the grocery tree when it is placed on the ground).
- A pre-made form to note down observations during the filling process (appendix VIII).
- The prototype.
- 250 g mushrooms in an open tray or basket.
- A paper and pen to write down the answers from the interviews.

Set-up analysis results
The actions with the packaging are analysed, and the most occurring actions noted down in the results. The answers to the interview questions are summarized and paraphrased per consumer per question. In the results, the explained answers are connected with observations from the usability test. The observations and interview results of the participants can be found in appendix VIII A.

A remark on the amount of participants. The amount of tests are not enough to make validated and significant proven conclusions, but collected data provides valuable insights on how to improve the packaging.

Hypothesis
It is likely that the participants hold the packaging in the intended first position (Figure 60). Holding the packaging from the cylindrical part, is assumed to be overlooked, because it is a new feature on a fruit and vegetable packaging.

Results
The usability test showed that there are multiple ways of interpreting the packaging and its features. The results are noted per stage of the usability test.

Grabbing the packaging.
The packaging is either grabbed from the box with two hands, or with one hand. In both situations, the packaging was grabbed by the complete body of the packaging.

Opening of the packaging.
All of the participants opened the lid of the packaging by grabbing the overhanging part of the lid (Figure 55). The interviewees added, that the shape informed them on where to grab and open the packaging.

Filling the packaging
Three ways of holding the packaging during filling it were observed. One held the complete packaging on the underside of the basket, others hold it with their thumb on the green triangle part with their other fingers below the packaging (Figure 60, position one), and the remaining participants hold the packaging by the cylindrical part (Figure 60, position two). The participants were asked why the packaging was held in those positions, the following was stated:

- For stability in holding the packaging
- The way the lid opens, forces you to hold it in the"first or second position".
- Hands are to small to grab the complete packaging comfortably, which is why this participant preferred holding the packaging in "position two".

From the interviews is noted that the cylindrical part of the packaging must be made bigger to make it more convenient.

Closing the lid
This was done, either by taking the overhanging part of the lid with two fingers or by grabbing the complete lid on the edges and folding it shut. None of the participants named the green edge of the lid, only the shape of the overhanging part of the lid.

The green colour of the features and use-cues were recognised by a couple of the participants. They explained that the colour and certain shapes of the packaging inform on how to hold and open the packaging. Other participants, thought the parts were green because of appearance reasons.

Convenience of the packaging
Most of the participants found it a convenient reusable packaging, but a concern about the ability to clean the packaging was shared. Convenience in cleaning the packaging was found the be an important judgment criterion about the convenience of reusable packaging.

12.3 Recommendations packaging

Conclusion
From the usability evaluation test, can be concluded that the set hypothesis was wrong. According to the results, the packaging was held in both positions (position one and position two), as in an additional position. The participants did not name the green coloured use-cues during the use test, only afterward some of the participants acknowledged to recognize some coloured parts as use-cues. During the test, the colours were not named as use-cues, which is why no conclusions and recommendations are make of it. The shape of the overhanging part of the lid and the diagonal shape of where the lid is attached, was seen as use-cue on how to hold and open the packaging. A higher convenience in holding the packaging can be achieved by making the cylindrical part bigger. The partipants had one concern about the reusable packaging, which was the ability to wash the packaging inside the dishwasher.

Discussion usability evaluation test
The usability evaluation test was conducted with five participants. This amount is to low to get validated results, which was proven with this test because every participant had different answers. Qualitative research can be concluded if no new answers come up during test and or interviews.

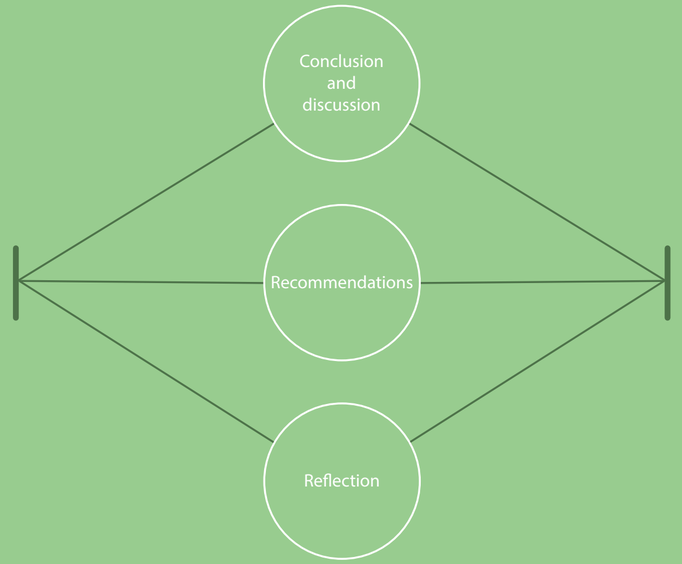
The prototype was taken from a box, and not from the grocery tree. This influences the ways of freedom in grabbing the packaging. This could have been limited if it was hanged from the grocery tree. Still, most participants either took the packaging from the front or took it by clamping the sides of the packaging with either one or two hands. The shape and size of the prototype were the same as the intended shape and size, this was good in testing the convenience and handling of the participants with the packaging.

The prototype was not transparent, this could influence the level of convenience in filling of the packaging. The consumer may find it convenient to see through the packaging or the lid, on where the mushrooms are placed.

According to the conclusion, the use-cues were not always recognized as use-cues. This was deducted by whether or not the participants named the use-cue, but a use-cue does not need to be used consciously to be effective. More tests into the usefulness of the use-cues should be conducted.

The following recommendations could be implemented into the packaging of the grocery tree.

- A bigger cylindrical part, this would improve the convenience of holding the packaging from the cylindrical part.
- The green triangle part on top of the packaging could have an indent, this would guide the consumer on where to put his or her thumb. This could also support the consumer in guidance on how to hold the packaging.
- The packaging could have information on it or inside the app on how to clean the packaging.



13. Evaluating

13.1 Conclusion and discussion

Conclusion

The objective of this project was to design a reusable packaging solution for the fresh fruit and vegetable sector that maintains and/ or improves the current consumer experience with fruit and vegetable packaging. In the first research question, it was asked how to lower the environmental impact of a fruit or vegetable with or without packaging, considering every stakeholder from the grower to end-of-life. The environmental impact of a fruit or vegetable can be lowered by buying them unpackaged from a crate. After which the consumer puts it into a reusable packaging solution, that can can either be reused for the same or a different purpose. If fruits or vegetables are transported in a crate to the supermarket, the carbon footprint is lowered by more efficient transport, but the shelf life needs to be considered to prevent food waste. Also, food spillage could be countered if the consumer is given the ability to pick only the desired amount of food. A reusable packaging solution for the consumer decreases the amount of used packaging and thereby the generated packaging waste. If the packaging waste is decreased the emission of greenhouse gasses is lowered and the accumulation of microplastics in the environment is decreased. The grocery shopping experience is adapted by replacing bar code stickering by an interactive app and scale, this context saves material of stickering and keeps the packaging material clean. At the end-of-life, the sorting process and purity of the material influences the recyclability of the material, which is why a packaging must be made of one material and kept free from stickers and advertisement. In short, the environmental impact of a fruit or vegetable can be lowered if they are packaged by the consumer with a reusable packaging solution from a grocery shop with an adapted context to reusable packaging shopping. This saves material, food waste, the emission of greenhouse gasses and the slows the accumulation of microplastics in the environment.

The consumer experience with a reusable packaging solution was researched with the second research question in which is asked, how to maintain or improve the consumer experience with a multiple-use packaging solution. The reusable packaging experience is maintained and improved by taking away the threshold values and inconveniences with reusable packaging. The skill in the filling of the packaging and room for bulk storage are the main threshold values, which can be overcome by having a convenient packaging in opening and resealing, but can also decrease is the size. Most inconveniences with packaging were concluded to be opening and resealing. In consumer research was found that the consumer lacks knowledge about packaging features and knowledge about sustainability in packaging, which is why it is concluded that reusable packaging needs to have clear instructions on the use and an adapted context to support processes concerning grocery shopping with reusable packaging. To conclude, the consumer experience with a multiple-use packaging is supported by a packaging that is convenient in opening and resealing, while having clear instructions in the use and works with an adapted grocery shop. Also, the packaging solution should be able to decrease is the size.

The grocery tree is designed to support the consumer in its journey from home to buying and storing fruits and vegetables. The grocery tree gives an answer to the set assignment, it is reusable and according to a usability evaluation test the packaging was found to be convenient to a certain degree. Also, it eliminates the use of single-use packaging in the fruit and vegetable sector. The grocery tree saves packaging material, bar code stickering material, food spillage, and packaging waste. This by letting consumers pick their own desired amount of food and having a reusable packaging. The packaging has predefined ways of holding it and the use-cues inform and support the consumer in the use of the packaging. The packaging opens diagonal and has the ability to be held stabile while the lid of the packaging is open, this to assist the consumer in the threshold of skill in filling of the packaging.

In short, this thesis gives an answer to how single-use packaging in the fresh fruits and vegetable sector can be replaced by a reusable packaging solution that supports the consumer in the use of reusable packaging solution.

Discussion

The approach in which this project is done is almost as it is noted in the report. A remark is that not all the researched information has contributed to the final design. Multiple chapters have been put in the appendix, because the first written assignment had a wide scope. Time could have been saved if the assignment was written about reusable packaging at the beginning of the project. The approach of the project was not noted clearly at the beginning of the project which resulted in a long analysis phase, which had not been neccessary.

Packaging choice for a fruit or vegetable

In the chapter “4. Benchmarking current fruit and vegetable packaging”„ the focus is laid on the mushroom. This decision is based on one criterion, shelf life. In previous iterations more criteria were used, however, these criteria were found incomplete and/ or subjective. The sources used to base shelf life criteria on, were not research papers, but information from organisations who advise consumers on how to store their food. The objectiveness of these sources can be questioned. However in the limited time of the project the decision was made to use those sources. I do not think research papers would have created different results, this because of own experiences with shelf lifes of the fruits and vegetables. In chapter “4.7 Design thoughts behind the iconic blue mushroom container”, an interview about the blue mushroom packaging was taken. If this interview had been done earlier in that phase of the project, the research into the different packaging could have been more narrow, which could have resulted in more in dept insights into packaging.

Consumer research

The consumer research was set up to get information about consumer involvement with sustainability, and to discover consumer experiences. Interviews were taken with 16 consumers, which is not enough to make objective conclusions that represent all consumers from The Netherlands. Semi-qualitative structured interviews were conducted, but some questions could have been asked by quantitative research, in which more answers could have been collected in a relatively short amount of time. Quantitative research could have resulted in objective data that represented the Dutch consumers.

The assignment was redefined after the consumer research was performed. This meant that from the interviews, questions and answers needed to be selected that would still support the questions in the new research set-up. Most questions did give use full answers to the new consumer research set-up, but if the consumer research could have been repeated, more direct questions about reusable packaging features could have been asked. The retrieved results from the interviews did match the insights retrieved from the literature research, which means that the selected interview questions did get results that substaintiaded other research. However, more argumentation about reusable packaging could have been retrieved with different interview questions.

Fruit and vegetable journey

The research of the fruit and vegetable journey was mostly based on interviews with the stakeholders. After the assignment was changed from a packaging solution to a reusable packaging solution, the needed information from the stakeholders changed as well. The interview questions were analysed and the information used that supported the new project assignment. Although interesting key findings were deducted from the fruit and vegetable journey, no in dept information was retrieved in those interviews, except for the intervie with the disposal company. It raises the question if more interesting key findings could have been retrieved if questions concerning reusable packaging were asked. Also, per stakeholder only one company was interviewed, which is a severe restriction in the validity of the information.

Information system

The journey of the consumer inside the app is detailed and the appearance of the screens designed. It was decided to keep the embodiment of the app and scale relatively short because more time was put in the embodiment of the grocery tree and the packaging. The app is compared to one existing grocery app, this is a restriction in results. This because other service apps could be more clear and convenient. To have more validated results the grocery tree app should be compared with more service apps.

13.2 Recommendations

The usability evaluation test
The usability evaluation test was taken with five participants. This amount is too low to get valid results, which was proven with the test because with every participant new answers were discovered. Qualitative research can be concluded if no new answers come up during test and or interviews. Because of the low number of participants, it only gives an idea of the convenience of the packaging, but upfront of the complete project a larger evaluation was wished for. The prototype was taken from a box, and not from the grocery tree. This influences the ways of freedom in grabbing the packaging. This could have been limited if it was hanged from the grocery tree. Still, most participants either took the packaging from the front or took it by clamping the sides of the packaging with either one or two hands.

The prototype was not transparent, this could influence the level of convenience in filling of the packaging. The consumer may find it convenient to see through the packaging or the lid, on where the mushrooms are placed. As resulted from chapter “4. Benchmarking current Fruit & Vegetables packaging”. The consumer has preference for a transparent packaging.

The grocery tree
The grocery tree is designed to be a grocery bag and packaging in one. The decision was made to hang the packaging on the outside of the tree, this means the packaging need to be strong enough no to break from the tree by impact, for example during transport. It needs to be tested if they are strong enough and if they are convenient in use. It was intended to have the packaging hanged in the tree almost against each other, but because of the shape of the packaging and tree itself they do not hang as close to each other as they were intended, this could influence the perceived convenience and strength of the grocery tree. Each of the designed packaging have a square shape, which may not be the most efficient shape for every fruit or vegetable.

The design of the grocery still offers room for improvement, therefore recommendations are given inside the following categories; additional research, development of the grocery tree, and further testing.

Additional research
To make reusable packaging more fit to package multiple kinds of fruits and vegetables, research into the demands of other fruits and vegetables needs to be performed.

In the report is stated, that fruits and vegetables are sold unpackaged inside the supermarket, but it is not researched what the effect of not packaging fruits and vegetables is on the fruits and vegetables itself. Further research into the positives and negatives of unpackaged fruits and vegetables could be researched. A list could be made which states what fruits and vegetables are fit for unpacked ways of selling, and which fruits and vegetables need to be sold from inside the refrigerator.

Consumer research was performed in consumer involvement with reusable packaging, but the questions asked to the consumers were not directly aimed at reusable packaging. To gather more insights about reusable packaging features and experiences, additional interviews should be conducted.

As mentioned in the chapter “13,2 Conclusion and discussion”, the fruit and vegetable journey was based on interviews performed before adjusting the assignment into a reusable packaging. To gather more ideas on how the different stakeholders think about reusable packaging, more interviews should be performed.

Development of the grocery tree
The grocery tree was designed to have the tree and the packaging integrated as one product. The shape of the grocery tree must be defined in a way that the packaging hangs closer together. This will make the grocery tree more whole and make it appear more strong and convenient.

The flexibility of the grocery tree depends on the different packaging sizes. Research should be performed in the desired dimensions and shapes, to develop other packaging. Also, the packaging should be developed further into a packaging that can decrease in size, this benefits the threshold of no room for storage of a reusable packaging.

The grocery tree is analysed with forces applied to it. The design was altered after that test, another stress analysis should be performed to see how the grocery performs. The design of the tree needs to be revisited to make it a more efficient structure that could be produced by extrusion. After the second stress analysis, it is advised to make a cost price prediction. The cost price will give in the feasibility of integrating the grocery tree in the fruits and vegetable shopping experience.

To verify the effect in savings of the grocery tree with its reusable packaging, a life cycle assessment should be performed. Facts about the savings with the use of the grocery tree could motivate the consumer to use it. The consumer wanted more transparency, which can be achieved by naming facts about savings.

It is advised to test the screens of the app on convenience. What may seem logical can be perceived illogical in use.

The feasibility of the scale should be tested by making a prototype. With the prototype and the app a test can be set up to test the convenience inside the supermarket.

From the usability test in chapter “12,2 Usability test”, the consumers asked if the packaging can be cleaned inside the dishwasher. In further developments, the availability to clean the packaging inside the dishwasher should be researched and tested. This to convince the consumer of the convenience of the reusable packaging.

Further testing
In chapter “12.2 Usability test”, was concluded that the test should be repeated with more participants. Also, the quantitative test could be performed to test if people recognise and understand the meaning of the use-cues.

The convenience and efficiency inside the supermarket could be tested by making a prototype of the app and the scale. The attitude of the consumer towards such a system could be tested then as well.

In chapter “9.2 Criteria”, is stated that the packaging must be understood by the consumer under 5 minutes. This test is advised to be performed, to get more clarity of what the consumer does and does not understand or observes from the packaging.

13.3 Reflection

The project is concluded with a personal reflection on my performance and learning experiences during the project.

Personal reflection
This graduation has given me the opportunity to use the skills I acquired in the previous years of study at industrial design. Looking back at the previous weeks I learned a lot, especially from my mistakes.

This project started with the company "Kordaat Product Design", who decided to turn their activities down, which forced me to continue the project on my own. In the first ten weeks, I was able to discuss my ideas and thoughts with the employees of the company, but after that split, I could not do that anymore. This development thaught me the importance of communication. When I was working alone, at some point I could not see my mistakes and I was insecure about delivering unfinished work to my chair and mentor. This was a mistake because feedback improves your work. A learning point is that I should dare to share my work and discuss the results, even if it is not finished or perfect in the way I want it to be.

Working alone was though sometimes, I had to motivate myself to start working, which was easier when I got a rhythm. Having to deal with a project this big on my own made me insecure because this was the first individual project of this size. At the beginning I discussed that I would stick to my planning and would not work too many hours a day, however in the last 10 weeks I was not able to keep this promise. I made long days and short nights until I got a result that was satisfying to me. In the end, I am glad about my working efforts and to have the flexibility to deal with setbacks. Although, the negative feedback moments made me question my writing abilities as my industrial design skills, in the last weeks more positive feedback was given which gave me a positive boost. Breaks are important, this was something that I had to repeat to myself because I tend to work for too many hours without any break. When I started to plan breaks during work, the efficient working time increased.

From the multiple feedback moments, it was discovered that I find too many things interesting and do not know when to stop searching, a learning point for me is to plan on what I need to know and into which directions I should do research. This will help me narrow the focus and to do research only into the desired information. In the consumer research I learned the importance of asking the right questions.

Making a CAD model was not something I prefer doing, but in this project I discovered more possibilities of the program and thereby started to appreciate it more. I am glad I put more effort than first intended in the CAD model, because the transition of a CAD model to a 3D printer prototype created more insights.

Writing a report is a skill that I have difficulties with. This project pushed me to improve my writing skills. The intention was to write in a scientific way in which I can still improve. Following some English lessons could help me in future projects. I am always striving for perfection and therefore I want to know and report every detail. That is why I spent to much time on some of the project phases. Although I like putting a report togheter especially with visuals. I learned in this project how to make visuals more quickly.

Planning a project of half a year on your own was found difficult. The main problem was the time project activities took. Almost all projects during the bachelor's and masters were group projects, in which processes can go fast. When taking on these processes alone, they take a lot more time, which was difficult to plan. Also, not making deadlines that I set for myself was disappointing sometimes, because you won't be able to finish parts, which in the end still had to be corrected. During the project, I managed to make more feasible plannings.

Learning experiences
- Keep an open mind throughout the project.
- How to plan a relatively large project.
- Dare to discuss unfinished work.
- The importance of a clear focus in the project.
- Make visuals more quickly.
- Obtained more knowledge and experience in SolidWorks.
- 3D printing.

Bibliography

Afvalfonds verpakkingen. (2017). Monitoring verpakkingen resultaten inzameling en recycling 2016 (1.0). Retrieved from https://afvalfondsverpakkingen.nl/monitoring/monitoringsrapportage

Arnoud, J. (2015, July 20). Nieuwe verpakking verlengt houdbaarheid champignons. Retrieved May 11, 2019, from https://www.groentennieuws.nl/article/128478/nieuwe-verpakking-verlengt-houdbaarheid-champignons/

Arthur, C., Baker, J., & Bamford, H. (2009). Proceedings of the International Research Workshop on the Occurrence, Effects, and Fate of Microplastic Marine Debris. Retrieved from http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR1_en.pdf

Back to the roots. (n.d.). OUR AWARD-WINNING MUSHROOM KIT NOW COMES IN A 2-PACK! GROW DELICIOUS, ORGANIC MUSHROOMS IN JUST 10 DAYS! Retrieved May 11, 2019, from https://backtotheroots.com/collections/mushroom-grow-kits/products/mushroom-kit-2-pack-holiday-variety-edition

Banken Champignons B.V.. (n.d.-a). White mushroom. Retrieved January 16, 2019, from https://www.bankenchampignons.com/en/our-products/white-mushroom-2/

Banken Champignons B.V.. (n.d.-b). Champignon, Kastanje. Retrieved May 10, 2019, from https://www.bankenchampignons.com/nl/assortiment/kastanjechampignon/

Banken Champignons B.V.. (n.d.-c). Cantharellen. Retrieved May 11, 2019, from https://www.bankenchampignons.com/nl/assortiment/cantharellen/

BASF. (n.d.). Chemical recycling of plastic waste. Retrieved January 16, 2019, from https://www.basf.com/global/en/who-we-are/sustainability/management-and-instruments/circular-economy/chemcycling.html

Beitzen-Heineke, E. F., Balta-Ozkan, N., & Reefke, H. (2017). The prospects of zero-packaging grocery stores to improve the social and environmental impacts of the food supply chain. Journal of Cleaner Production, 140, 1528–1541. https://doi.org/10.1016/j.jclepro.2016.09.227

Beverloo, V. (2013, October 24). Local-for-local: het nieuwe outsourcen. Retrieved May 25, 2019, from https://privacy.vakmedianet.nl/logistiek/?ref=https://www.logistiek.nl/supply-chain/blog/2013/10/local-for-local-het-nieuwe-outsourcen-101130565

Bohlmann, G. M. (2004). Biodegradable packaging life-cycle assessment. Environmental Progress, 23(4), 342–346. https://doi.org/10.1002/ep.10053

Boffey, D. (2018, January 16). EU declares war on plastic waste. Retrieved May 29, 2019, from https://www.theguardian.com/environment/2018/jan/16/eu-declares-war-on-plastic-waste-2030

Brisson, I. (1993). Pac kaging waste and the environment: economics and policy. Resources, Conservation and Recycling, 8(3-4), 183–292. https://doi.org/10.1016/0921-3449(93)90026-c

Burton, K., & Noble, R. (1993). The influence of flush number, bruising and storage temperature on mushroom quality. Postharvest Biology and Technology, 3(1), 39–47. https://doi.org/10.1016/0925-5214(93)90025-x

Carrefour. (2018). Nieuwe verpakking voor onze bio champignons [Photograph]. Retrieved May 11, 2019, from https://www.carrefour.eu/nl/carrefour-en-jij/producten/bio/bio-champignons.html

CBS. (2018, December 18). Forecast: 18 million inhabitants in 2029. Retrieved May 29, 2019, from https://www.cbs.nl/en-gb/news/2018/51/forecast-18-million-inhabitants-in-2029

Centraal Bureau voor de Statistiek. (2018a, December 12). Gemeentelijke afvalstoffen; hoeveelheden. Retrieved April 21, 2019, from https://opendata.cbs.nl/statline/

Centraal Bureau voor de Statistiek. (2018b, November 12). Huishoudens; grootte, samenstelling, positie in het huishouden, 1 januari. Retrieved June 10, 2019, from https://www.volksgezondheidenzorg.info/onderwerp/bevolking/cijfers-context/huishoudens

Ces Edupack. (2018)

Champoord B.V.. (n.d.). Vers champignons. Retrieved June 25, 2019, from https://www.champoord.nl/prod_vers_champignons.html

CPB. (2017, September 20). Meer plastic inzamelen levert beperkte milieuwinst: innovaties geboden. Retrieved November 20, 2018, from https://www.cpb.nl/persbericht/meer-plastic-inzamelen-levert-beperkte-milieuwinst-innovaties-geboden

Curver Ltd.. (2015, December 7). Everything you need to know about the symbols on our plastic containers. Retrieved May 11, 2019, from https://www.curver.com/cur/about-plastic/everything-you-need-to-know-about-the-symbols-on-our-plastic-containers/

Deloitte Accountantcy & Advies B.V.. (2015). Consumentenonderzoek 2015. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/nl/Documents/consumer-business/deloitte-nl-cb-consumentenonderzoek-2015.pdf

De Waart, S., De Jong, W., & Tijs, M. (2015). Zwerfafval. Retrieved from https://www.kidv.nl/4788/bijlage-a-zwerfafval.pdf

DeWeerdt, S. (2018, August 7). Plastic trash is the latest source of greenhouse gas. Retrieved February 12, 2019, from http://www.anthropocenemagazine.org/2018/08/plastic-trash-is-the-latest-source-of-greenhouse-gas/

DINED. (2004). DINED [Dataset]. Retrieved June 19, 2019, from https://dined.io.tudelft.nl/en/database/tool

Dormer, A., Finn, D. P., Ward, P., & Cullen, J. (2013). Carbon footprint analysis in plastics manufacturing. Journal of Cleaner Production, 51, 133–141. https://doi.org/10.1016/j.jclepro.2013.01.014

Eat By Date. (n.d.-a). How Long Do Apples Last? Retrieved May 8, 2019, from http://www.eatbydate.com/fruits/fresh/apples-shelf-life-expiration-date/

Eat By Date. (n.d.-b). How Long Do Blueberries Last? Retrieved May 8, 2019, from http://www.eatbydate.com/fruits/fresh/blueberries/

Eat By Date. (n.d.-c). How long do Grapes last? Retrieved July 4, 2019, from http://www.eatbydate.com/fruits/fresh/grapes/

Eat By Date. (n.d.-d). How Long Does Kiwi Last? Retrieved July 4, 2019, from http://www.eatbydate.com/fruits/fresh/kiwi/

Eat By Date. (n.d.-e). How Long Do Mushrooms Last? Retrieved July 4, 2019, from http://www.eatbydate.com/vegetables/fresh-vegetables/mushrooms/

Eat By Date. (n.d.-f). How Long Do Onions Last? Retrieved July 4, 2019, from http://www.eatbydate.com/vegetables/fresh-vegetables/how-long-do-onions-last-shelf-life/

Eat By Date. (n.d.-g). How Long Do Tomatoes Last? Retrieved July 4, 2019, from http://www.eatbydate.com/fruits/fresh/tomatoes-shelf-life-expiration-date//

Eat By Date. (n.d.-h). How Long Do Strawberries Last? Retrieved July 4, 2019, from http://www.eatbydate.com/fruits/fresh/how-long-do-strawberries-last/

Effie awards. (n.d.). Plastic Heroes Campagne. Retrieved April 20, 2019, from https://www.effie.nl/bekroond/plastic-heroes-campagne

Ellen MacArthur, D., Waughray, D., & Stuchtey, M. (2016). The New Plastics Economy — Rethinking the future of plastics. Retrieved from http://www.ellenmacarthurfoundation.org/publications

EPA. (n.d.). Overview of Greenhouse Gases. Retrieved February 12, 2019, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases

Erich, M. (2012). Food 2030. Retrieved from https://www.ing.nl/media/ING_EBZ_Food_2030_Samenwerking_vanuit_een_nieuwe_mindset_tcm162-52911.pdf

Ertz, M., Huang, R., Jo, M., Karakas, F., & Sarigöllü, E. (2017). From single-use to multi-use: Study of consumers' behavior toward consumption of reusable containers. Journal of Environmental Management, 193, 334–344. https://doi.org/10.1016/j.jenvman.2017.01.060

Eufrin. (2011). The Role of the European Fruit Sector in Europe 2030. Retrieved from http://eufrin.eu/index.php?id=8

European Commission. (2011). Plastic Waste: Ecological and Human Health Impacts. Retrieved from http://ec.europa.eu/environment/integration/research/newsalert/pdf/IR1_en.pdf

Europees Parlement. (2018, October 12). Plasticsoep: feiten, gevolgen en aanpak. Retrieved April 20, 2019, from http://www.europarl.europa.eu/news/nl/headlines/society/20181005STO15110/plasticsoep-feiten-gevolgen-en-aanpak

European Parliament. (2018, November 22). Microplastics: sources, effects and solutions [Dataset]. Retrieved April 22, 2019, from http://www.europarl.europa.eu/news/en/headlines/society/20181116STO19217/microplastics-sources-effects-and-solutions

Freudenrich, C. (2000, October 16). How Landfills Work. Retrieved November 20, 2018, from https://science.howstuffworks.com/environmental/green-science/landfill3.htm

Groentenfruit Huis. (2019). Position paper. Retrieved from https://groentenfruithuis.nl/files/3441/GroentenFruit-Huis-Position-Paper-Voedselverspilling-14-januari-2019.pdf

Grigore, M. (2017). Methods of Recycling, Properties and Applications of Recycled Thermoplastic Polymers. Recycling, 2(4), 24. https://doi.org/10.3390/recycling2040024

Grunow, M., & Piramuthu, S. (2013). RFID in highly perishable food supply chains – Remaining shelf life to supplant expiry date? International Journal of Production Economics, 146(2), 717–727. https://doi.org/10.1016/j.ijpe.2013.08.028

Haffmans, S., Van Gelder, M., Van Hinte, E., & Zijlstra, Y. (2018). Products That Flow: Circular Business Models and Design Strategies for Fast Moving Consumer Goods. Amsterdam, The Netherlands: Bis B.V., Uitgeverij (BIS Publishers).

Hall, D. (2017, March 13). Throwaway culture has spread packaging waste worldwide: here's what to do about it. Retrieved November 12, 2018, from https://www.theguardian.com/environment/2017/mar/13/waste-plastic-food-packaging-recycling-throwaway-culture-dave-hall

Hopewell, J., Dvorak, R., & Kosior, E. (2009). Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society B: Biological Sciences, 364(1526), 2115–2126. https://doi.org/10.1098/rstb.2008.0311

Ketelslegers, R. (2018, February 5). Mushroom branch says farewell to polystyrene. Retrieved May 10, 2019, from https://www.freshplaza.com/article/2193876/mushroom-branch-says-farewell-to-polystyrene/

KIDV. (2018). Chemische recycling van kunststof verpakkingen. Retrieved from https://www.kidv.nl/8199

Kim, K. M., Ko, J. A., Lee, J. S., Park, H. J., & Hanna, M. A. (2006). Effect of modified atmosphere packaging on the shelf-life of coated, whole and sliced mushrooms. LWT, 39(4), 365–372. https://doi.org/10.1016/j.lwt.2005.02.015
Kirwan, M. J., Coles, R., & McDowell, D. (2003). Food Packaging Technology. https://doi.org/10.1002/jsfa.2089

Klein, S., Dimzon, I. K., Eubeler, J., & Knepper, T. P. (2017). Analysis, Occurrence, and Degradation of Microplastics in the Aqueous Environment. The Handbook of Environmental Chemistry, , 51–67. https://doi.org/10.1007/978-3-319-61615-5_3

Kumari, L., Narsaiah, K., Grewal, M., & Anurag, R. (2015). Application of RFID in agri-food sector. Trends in Food Science & Technology, 43(2), 144–161. https://doi.org/10.1016/j.tifs.2015.02.005

Lindh, H., Olsson, A., & Williams, H. (2015). Consumer Perceptions of Food Packaging: Contributing to or Counteracting Environmentally Sustainable Development? Packaging Technology and Science, 29(1), 3–23. https://doi.org/10.1002/pts.2184

Lin, Q., Lu, Y., Zhang, J., Liu, W., Guan, W., & Wang, Z. (2017). Effects of high CO 2 in-package treatment on flavor, quality and antioxidant activity of button mushroom (Agaricus bisporus) during postharvest storage. Postharvest Biology and Technology, 123, 112–118. https://doi.org/10.1016/j.postharvbio.2016.09.006

Lofthouse, V., & Bhamra, T. (2006). An investigation into consumer perceptions of refills and refillable packaging. Retrieved from https://www.researchgate.net/publication/237122264_An_investigation_into_consumer_perceptions_of_refills_and_refillable_packaging

Mahajan, P., Oliveira, F., & Macedo, I. (2008). Effect of temperature and humidity on the transpiration rate of the whole mushrooms. Journal of Food Engineering, 84(2), 281–288. https://doi.org/10.1016/j.jfoodeng.2007.05.021

Marsh, K., & Bugusu, B. (2007). Food Packaging?Roles, Materials, and Environmental Issues. Journal of Food Science, 72(3), 39–55. https://doi.org/10.1111/j.1750-3841.2007.00301.x

Martinho, G., Pires, A., Portela, G., & Fonseca, M. (2015). Factors affecting consumers' choices concerning sustainable packaging during product purchase and recycling. Resources, Conservation and Recycling, 103, 58–68. https://doi.org/10.1016/j.resconrec.2015.07.012

Meulendijks, A. (2016). Graduation Thesis Shopping without waste.

Milieu Centraal. (n.d.) Zwerfafval Retrieved November 17, 2018, from https://www.milieucentraal.nl/minder-afval/voorkom-afval/zwerfafval/

Milieu Centraal, & Voedingscentrum. (2017). Feiten en cijfers over verspillen van voedsel door consumenten in 2016. Retrieved from https://www.milieucentraal.nl/media/3725/factsheet-voedselverspilling-huishoudens-mei-2017.pdf
Milieu Centraal. (2017). Feiten en cijfers over verspillen van voedsel door consumenten in 2016. Retrieved from https://www.milieucentraal.nl/media/3725/factsheet-voedselverspilling-huishoudens-mei-2017.pdf

Nederlandse Voedsel- en Warenautoriteit. (2017, March 9). Voorverpakte levensmiddelen: verplichte vermeldingen. Retrieved May 11, 2019, from https://www.nvwa.nl/onderwerpen/etikettering-van-levensmiddelen/voorverpakte-levensmiddelen-verplichte-vermeldingen

NRK Recycling. (2015). Kunststof recyclingindustrie in Nederland. Retrieved from http://kunststofkringloop.nl/wp-content/uploads/2014/05/nrk_recycling_brochure_05.pdf

Ntinas, G. K., Neumair, M., Tsadilas, C. D., & Meyer, J. (2017). Carbon footprint and cumulative energy demand of greenhouse and open-field tomato cultivation systems under Southern and Central European climatic conditions. Journal of Cleaner Production, 142, 3617–3626. https://doi.org/10.1016/j.jclepro.2016.10.106

Nunez, C. (n.d.). What Is Global Warming? Retrieved February 11, 2019, from https://www.nationalgeographic.com/environment/global-warming/global-warming-overview/

Oliveira, F., Sousa-Gallagher, M., Mahajan, P., & Teixeira, J. (2012). Development of shelf-life kinetic model for modified atmosphere packaging of fresh sliced mushrooms. Journal of Food Engineering, 111(2), 466–473. https://doi.org/10.1016/j.jfoodeng.2012.01.013

Osman, I., Osman, S., Mokhtar, I., Setapa, F., Shukor, S. A. M., & Temyati, Z. (2014). Family Food Consumption: Desire towards Convenient Food Products. Procedia - Social and Behavioral Sciences, 121, 223–231. https://doi.org/10.1016/j.sbspro.2014.01.1123

Pachauri, R. K., The Core Writing Team, & Reisinger, A. (2008). Climate Change 2007: Synthesis Report. Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/ar4_syr_full_report.pdf

Packaging World. (2016, February 15). Six packaging trends for 2016. Retrieved May 29, 2019, from https://www.packworld.com/article/trends-and-issues/global/six-packaging-trends-2016

Payne, T. (2018, June 4). The evolving warehouse and future trends. Retrieved May 28, 2019, from https://www.explorewms.com/warehouse-future-trends.html

PET Resin Association. (2015). The Science Behind PET. Retrieved March 27, 2019, from http://www.petresin.org/science_behindpet.asp

PlasticsEurope. (2015). Plastics- the Facts 2015. Retrieved from https://www.plasticseurope.org/application/files/3715/1689/8308/2015plastics_the_facts_14122015.pdf

PlasticsEurope. (n.d.). RECYCLING EN ENERGIETERUGWINNING. Retrieved January 15, 2019, from https://www.plasticseurope.org/nl/focus-areas/circular-economy/zero-plastics-landfill/recycling-and-energy-recovery

Poel, E. (2016, September 1). Slim inspelen op vier trends in supermarktbranche. Retrieved May 25, 2019, from https://privacy.vakmedianet.nl/distrifood/?ref=https://www.distrifood.nl/branche-bedrijf/blog/2016/09/slim-inspelen-op-vier-trends-in-supermarktbranche-101100661

Pongrácz, E. (2007). THE ENVIRONMENTAL IMPACTS OF PACKAGING. Environmentally Conscious Materials and Chemicals Processing, 1, 237–278. https://doi.org/10.1002/9780470168219.ch9

Van Boeijen, A., Daalhuizen, J., Van der Schoor, R., & Zijlstra, J. (2014). Delft Design Guide: Design Strategies and Methods (2nd ed.). Amsterdam, Netherlands: Bis B.V., Uitgeverij (BIS Publishers).

Van den Berg, W., & Schutter, R. (2010). Product-info champignon. Retrieved from http://edepot.wur.nl/283203

Van Diemen, E. (2018, October 1). Vermindering voedselverspilling – de supermarkten zijn aan zet [Blog post]. Retrieved April 24, 2019, from https://privacy.vakmedianet.nl/distrifood/?ref=https://www.distrifood.nl/branche-bedrijf/blog/2018/10/vermindering-voedselverspilling-de-supermarkten-zijn-aan-zet-101119285

Rabobank. (n.d.). Supermarkten. Retrieved May 25, 2019, from https://www.rabobank.nl/bedrijven/cijfers-en-trends/food/supermarkten/

Ragaert, K., Delva, L., & Van Geem, K. (2017). Mechanical and chemical recycling of solid plastic waste. Waste Management, 69, 24–58. https://doi.org/10.1016/j.wasman.2017.07.04

Recycling.nl. (n.d.). Wat is PS polystyreen. Retrieved January 15, 2019, from http://www.recycling.nl/recycling/ps-polystyreen-recycling/wat-is-ps-polystyreen.html

Rijksinstituut voor Volksgezondheid en Milieu. (2018). Voedselconsumptie 2012 - 2016. Retrieved from https://www.rivm.nl/sites/default/files/2018-11/Factsheet%20Voedselconsumptie%202012%20-%202016%20Wat%2C%20waar%20en%20wanneer.pdf

Rijksoverheid. (2019, January 25). Emissies broeikasgassen, 1990-2017. Retrieved April 23, 2019, from https://www.clo.nl/indicatoren/nlo165-broeikasgasemissies-in-nederland

Rijksoverheid. (2016, January 1). Verbod op gratis plastic tassen. Retrieved April 20, 2019, from https://www.rijksoverheid.nl/onderwerpen/afval/verbod-op-gratis-plastic-tassen

Rijkswaterstaat. (2013). Nederlands afval in cijfers, gegevens 2006-2010 (1.1). Retrieved from https://www.afvalcirculair.nl/onderwerpen/helpdesk-afvalbeheer/publicaties/downloads/downloads-0/nederlands-afval-1/

Rijkswaterstaat. (2017). Afvalstoffenheffing 2017 (1.0). Retrieved from https://www.afvalcirculair.nl/onderwerpen/helpdesk-afvalbeheer/publicaties/downloads/downloads-0/afvalstoffenheffing-4/

Rijkswaterstaat. (2018). Samenstelling van het huishoudelijk restafval, sorteeranalyses 2017 (1.0). Retrieved from https://www.afvalcirculair.nl/onderwerpen/helpdesk-afvalbeheer/publicaties/downloads/downloads-0/samenstelling-6/

Rijkswaterstaat. (n.d.). Afvalmonitor [Dataset]. Retrieved April 21, 2019, from https://afvalmonitor.databank.nl/Jive/Jive?cat_open=landelijk%20niveau/Samenstelling%20van%20huishoudelijk%20restafval

Rijstextiles. (n.d.-b). Tassenband Zwart 25mm (Per Meter). Retrieved July 8, 2019, from https://www.rijstextiles.com/nl/fournituren/tassenband/25mm-tassenband-polypropyleen/tassenband-zwart-25mm-per-meter.html

RIVM. (2016). Milieubelasting van de voedselconsumptie in Nederland (0074). Retrieved from https://www.rivm.nl/publicaties/milieubelasting-van-voedselconsumptie-in-nederland

Robinson, T., Cronin, T., Ibrahim, H., Jinks, M., Molitor, T., Newman, J., & Shapiro, J. (2013). Smartphone Use and Acceptability Among Clinical Medical Students: A Questionnaire-Based Study. Journal of Medical Systems, 37(3). https://doi.org/10.1007/s10916-013-9936-5

Rodhe, H. (1990). A Comparison of the Contribution of Various Gases to the Greenhouse Effect. Science, 248(4960), 1217–1219. https://doi.org/10.1126/science.248.4960.1217

RVO. (n.d.). Afvalverbranding. Retrieved November 19, 2018, from https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/bio-energie/technieken-en-toepassingen/afvalverbranding

Solidworks (2018)

Steenis, N. D., Van Herpen, E., Van der Lans, I. A., Ligthart, T. N., & Van Trijp, H. C. (2017). Consumer response to packaging design: The role of packaging materials and graphics in sustainability perceptions and product evaluations. Journal of Cleaner Production, 162, 286–298. https://doi.org/10.1016/j.jclepro.2017.06.036

Stenmarck, Å., Jensen, C., Quested, T., & Moates, G. (2016). Estimates of European food waste levels. | FUSIONS Reducing food waste through social innovation, 2–81. https://doi.org/10.13140/RG.2.1.4658.4721

Stepfive Communication. (2018, February 9). Innovative vitamin D mushrooms. Retrieved May 11, 2019, from https://blog.stepfive.nl/?p=1687

Strapworks.com. (n.d.). Polypropylene Webbing. Retrieved June 17, 2019, from https://www.strapworks.com/Polypropylene_Webbing_s/59.htm

Techopedia. (n.d.). End-of-Life Product (EOL Product). Retrieved November 19, 2018, from https://www.techopedia.com/definition/30051/end-of-life-product-eol-product

The Greenery. (n.d.-a). Organisatie. Retrieved February 26, 2018, from https://www.thegreenery.com/organisatie

The Greenery. (n.d.-b). Verpakkings-innovatie van eigen hand. Retrieved May 20, 2019, from https://www.thegreenery.com/cases/verpakkings-innovatie-van-eigen-hand

The Ocean Cleanup. (2019). [OVER 5 TRILLION PIECES OF PLASTIC CURRENTLY LITTER THE OCEAN]. Retrieved April 13, 2019, from https://www.theoceancleanup.com/

Thijssen, C. (2017, April 20). Tesco's nieuwe verpakking houdt champignons langer vers. Retrieved May 11, 2019, from https://www.duurzaambedrijfsleven.nl/agri-food/22399/tescos-nieuwe-verpakking-houdt-champignons-langer-vers

Tupperware. (n.d.). Smartclip Set. Retrieved August 6, 2019, from https://www.tupperware.nl/producten/alle-producten/2921/SmartclipSet

Van Asseldonk Champignons. (n.d.). Bedrijfsproces. Retrieved January 16, 2019, from http://www.vanasseldonkchampignons.nl/index.php/bedrijfsproces/

Van Boeijen, A., Daalhuizen, J., Zijlstra, J., & Van der Schoor, R. (2014). Delft Design Guide: Design Strategies and Methods (2nd ed.). Amsterdam, The Netherlands: Bis B.V., Uitgeverij (BIS Publishers).

Van Leusden, J., Van Tellingen, H., & Van der Weerd, J. (2017, January). Aandeel online omzet van supermarkten blijft beperkt. Retrieved May 29, 2019, from https://strabo.nl/assets/uploads/documents/Aandeelonlineomzet.pdf

Van den Berg, W., & Schutter, R. (2010). Product-

info champignon. Retrieved from http://edepot.wur.nl/283203

Vazquez-Briseno, M., I., F., De Dios Sanchez-Lopez, J., Jimenez-Garcia, E., Navarro-Cota, C., & Ivan, J. (2012). Using RFID/NFC and QR-Code in Mobile Phones to Link the Physical and the Digital World. Interactive Multimedia, . https://doi.org/10.5772/37447

Vink Kunststoffen. (n.d.). Kunststof herkennen [Photograph]. Retrieved May 10, 2019, from https://www.vinkkunststoffen.nl/kenniscentrum/kunststof-herkennen

Vinyl Council Australia. (n.d.). PVC Environmental Credentials. Retrieved March 27, 2019, from https://www.vinyl.org.au/pvc-dioxins

Voedingscentrum. (n.d.). Eten bewaren. Retrieved May 8, 2019, from https://www.voedingscentrum.nl/nl/mijn-boodschappen/eten-bewaren.aspx

Wageningen Food & Biobased Research. (2017). Monitor Voedselverspilling update 2009 - 2016 (Rapport 1822). Retrieved from https://www.wur.nl/upload_mm/8/2/a/762faac4-2efa-42de-8a91-a4a3896dfb85_Monitor%20Voedselverspilling%20Update%202009-2016.pdf

Wakefield, J. C. (2007). Styrene. Toxicological overview, 1. Retrieved from http://www.ladep.es/ficheros/documentos/Styrene%2C%20toxicological%20overview.%20

Bibliography figures

Angelucci, J. (2016, 23 september). Did You Know Pennsylvania is home to largest grower of specialty mushrooms in U.S.? [Foto]. Geraadpleegd op 19 mei 2019, van https://dced.pa.gov/paproudblog/did-you-know-pennsylvania-is-home-to-the-largest-grower-of-specialty-mushrooms/

BioForum Vlaanderen. (n.d.). Waarom zijn biologische groente en fruit in de supermarkt zo vaak verpakt? [Photograph]. Retrieved May 20, 2019, from https://biomijnnatuur.be/vragen-over-bio/waarom-zijn-biologische-groente-en-fruit-in-de-supermarkt-zo-vaak-verpakt

Coldewey, D. (2017, September 29). This edible sensor could help keep food fresh [Photograph]. Retrieved May 25, 2019, from https://techcrunch.com/2017/09/28/this-edible-sensor-could-help-keep-food-fresh/

Jonker, C. M. (n.d.-b). TUDelft [Photograph]. Retrieved July 9, 2019, from https://www.catholijnjonker.nl/institute/tudelft

Rijksoverheid. (2019, January 25). Emissies broeikasgassen, 1990-2017 [Illustration]. Retrieved April 23, 2019, from https://www.clo.nl/indicatoren/nl0165-broeikasgasemissies-in-nederland

The Mushroom Council. (n.d.). White Button [Photograph]. Retrieved May 9, 2019, from https://www.mushroomcouncil.com/varieties/white-button/

Van Looveren, Y. (2016, May 20). Nijmegen krijgt een Jumbo Foodmarkt [Photograph]. Retrieved May 20, 2019, from https://www.retaildetail.nl/nl/news/food/nijmegen-krijgt-een-jumbo-foodmarkt

Vink Kunststoffen. (n.d.). Kunststof herkennen [Photograph]. Retrieved May 10, 2019, from https://www.vinkkunststoffen.nl/kenniscentrum/kunststof-herkennen

Whitmuir Organics. (2019). Mushrooms Chestnut (250g) [Photograph]. Retrieved May 9, 2019, from https://www.whitmuir.scot/chestnut-mushrooms

Bibliography figures sustainable product collage

Borrás, J. (2018, November 8). Gogoro Scores DHL & Taiwan Post As Battery Swap Partners [Photograph]. Retrieved July 4, 2019, from https://cleantechnica.com/2018/11/08/gogoro-scores-dhl-taiwan-post-as-battery-swap-partners/

Coolblue B.V.. (n.d.). Toon thermostaat (inclusief installatie) [Photograph]. Retrieved July 4, 2019, from https://www.coolblue.nl/product/619823/toon-thermostaat-inclusief-installatie.html

ECO Soap Design Study [Photograph]. (2011, March 2). Retrieved July 4, 2019, from https://thedieline.com/blog/2011/2/3/eco-soap-design-study.html

Ever Eco 4-Pack Organic Cotton Net Produce Bags [Photograph]. (n.d.). Retrieved July 4, 2019, from https://www.anthropologie.com/shop/ever-eco-4-pack-organic-cotton-net-produce-bags

FLOW CHARGING. (n.d.). LAADPAAL ZAKELIJK SMART 11 KW [Photograph]. Retrieved July 4, 2019, from https://www.flowcharging.com/nl_be/product/laadpaal-zakelijk-smart-11-kw/

Freshique. (n.d.). Bamboo Straws [Photograph]. Retrieved July 4, 2019, from https://www.freshiqueorganics.com/products/bamboo-straws

Lavars, N. (2015, January 8). Gogoro Smartscooter counts on a network of battery-swap stations to stay on the move [Photograph]. Retrieved July 4, 2019, from https://newatlas.com/gogoro-smartscooter-battery-kiosks/35508/

Mason Jar Bamboo Lid and Straw [Photograph]. (n.d.). Retrieved July 4, 2019, from https://www.shopwildergoods.com/new-products/mason-jar-bamboo-lid-and-straw

Obelink Vrijetijdsmarkt. (n.d.). Dopper Original Apple Green [Photograph]. Retrieved July 4, 2019, from https://www.obelink.nl/dopper-original-apple-green.html

Packaging World. (2019, February 9). P&G designs 11 refillable, reusable products and packaging for Loop shopping platform [Photograph]. Retrieved July 4, 2019, from https://www.packworld.com/article/sustainability/reusability/pg-designs-11-refillable-reusable-products-and-packaging-loop

WEARTH LONDON LIMITED. (n.d.). Zero Waste Starter Kit [Photograph]. Retrieved July 4, 2019, from https://www.wearthlondon.com/zero-waste-gift-set

Bibliography time line chapter 7. Developments and trends analysis

[1] Yam, K. (2009). The Wiley encyclopedia of packaging technology (3rd ed., pp. 975, 1259-1265). Hoboken,N.J.: John Wiley & Sons.

[2] Althoff, M. (2006, November 30). Nederlandse barcode bestaat dertig jaar. Retrieved May 28, 2019, from https://www.logistiek.nl/warehousing/nieuws/2006/11/nederlandse-barcode-bestaat-dertig-jaar-10124145?vakmedianet-approve-cookies=1

[3] United Nations Environment Programme. (2018, April 25). From birth to ban: A history of the plastic shopping bag. Retrieved May 28, 2019, from https://www.unenvironment.org/news-and-stories/story/birth-ban-history-plastic-shopping-bag

[4] Meijsen, J. (2018, February 15). Geschiedenis van online foodverkoop. Retrieved May 28, 2019, from https://privacy.vakmedianet.nl/distrifood/?ref=https://www.distrifood.nl/branche-bedrijf/artikel/2018/02/geschiedenis-feiten-en-ontwikkelingen-in-online-foodverkoop-101112212

[5] Betaalvereniging Nederland. (n.d.). VAN PIN NAAR PINNEN. Retrieved May 28, 2019, from https://www.pin.nl/consument/historie-pinnen/

[6] Auras, R. A., Lim, L. T., Selke, S. E. M., & Tsuji, H. (2010). Poly(lactic acid): Synthesis, Structures, Properties, Processing, and Applications. Hoboken, N.J.: Wiley.

[7] Overheid.nl. (1997, November 8). Besluit stortplaatsen en stortverboden afvalstoffen. Retrieved May 28, 2019, from https://wetten.overheid.nl/BWBR0009094/2018-02-06

[8] Thijssen, W. (2003, January 2). Zelfscan-kassa maakt caissière overbodig. Retrieved May 28, 2019, from https://www.volkskrant.nl/economie/zelfscan-kassa-maakt-caissiere-overbodig~b4955c7c/

[8] Ministerie van Infrastructuur en Waterstaat. (2016, January 1). Verbod op gratis plastic tassen. Retrieved May 28, 2019, from https://www.rijksoverheid.nl/onderwerpen/afval/verbod-op-gratis-plastic-tassen

[9] Ministerie van Infrastructuur en Waterstaat. (2016, January 1). Verbod op gratis plastic tassen. Retrieved May 28, 2019, from https://www.rijksoverheid.nl/onderwerpen/afval/verbod-op-gratis-plastic-tassen

[10]American Chemistry Council Inc.. (2010, May 19). Plastic Packaging History: Innovations Through the Decades. Retrieved May 28, 2019, from https://www.plasticsmakeitpossible.com/about-plastics/history-of-plastics/plastic-innovations-in-packaging-through-the-decades/

[11] European Commission. (2014, April 6). LASER MARK - CREATING MARKET DEMAND FOR FRUITS LABELLED ECOLOGICALLY WITH INNOVATIVE LASER TECHNOLOGIES - Eco-Innovation - European Commission. Retrieved May 28, 2019, from https://ec.europa.eu/environment/eco-innovation/projects/en/projects/laser-mark

[12] HAK onthult definitief ontwerp HAK deksel. (2011, September 21). Retrieved May 28, 2019, from http://nieuws.hak.nl/hak-onthult-definitief-ontwerp-hak-deksel/

[13] De Nederlandsche Bank. (2016, March 22). DNBulletin: Contactloos betalen, straks overal in Europa - De Nederlandsche Bank. Retrieved May 28, 2019, from https://www.dnb.nl/nieuws/nieuwsoverzicht-en-archief/dnbulletin-2016/dnb339173.jsp

[14] Rensen, E. (2017, March 7). Hoogvliet 'verpakt' gember met laserlicht. Retrieved May 28, 2019, from https://privacy.vakmedianet.nl/distrifood/?ref=https://www.distrifood.nl/formules/nieuws/2017/03/hoogvliet-verpakt-gember-met-laserlicht-101105996

[15] Renewi. (2018, December 11). Chemische recycling gemengd plastic afval. Retrieved March 13, 2019, from https://www.verenigingafvalbedrijven.nl/nieuws/nieuwsbericht/fabriek-voor-chemische-recycling-gemengd-plastic-afval.html