Prepit

Reducing the environmental footprint of the Dutch diet

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Images frontpage

Variety of Fruits [Online image]. (2017). Canva. https://www.canva.com/media/MADGybQo8fs

[Untitled illustration of logo Prepit]. Facebook. https://www.facebook.com/prepitnl/

EXECUTIVE SUMMARY

This ACT project contributes to the aim of Prepit by filling in the knowledge gap on how the average CO2-eq emission of the Dutch diet can be reduced. The following main research question has been formulated: '*What knowledge is needed for Prepit to contribute to reducing the CO2-eq emissions of the Dutch diet?*'. In order to provide an answer to this research question, literature research was performed, interviews were held with experts, and a questionnaire was conducted among the Prepit community.

It has been found that it is not possible to give concrete, hard numbers on a certain product's CO2-eq emissions. However, different categories of fruits and vegetables can be compared on their average environmental impact. Factors of importance for estimating the CO2-eq of foods are greenhouse horticulture or open ground cultivation, transportation, seasonality, storage, and packaging. Furthermore, it has been found that Prepit should focus on tackling the barriers consumers are facing, such as lack or overload of information, perceived price, habits and the perception of the impact of an individual. Finally, it has been found that the problem of climate change should not be reduced to CO2-eq emissions alone since the problem is more complex than this. In order for Prepit to establish effective change the following other dimensions of sustainability are advised to be taken into account: food nutrients, biodiversity/environment/climate, equity/fair trade, eco-friendly/local/seasonal and cultural heritage/skills.

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DEFINITION LIST

CO2-equivalent (CO2-eq) CO2-eq does not only include carbon dioxide (CO2), but also various other greenhouse gasses. This includes nitrous oxide (N2O), methane (CH4) and multiple fluorinated gasses. In order to sum up the total impact on the environment of these different gasses, they are converted into a CO2-equivalent (Centraal Bureau van Statistiek, 2020).

Cradle to retail this concept includes the environmental impact of the product, expressed in the amount of CO2 equivalent emitted per kilogram of product. It includes the stages of a product from its origins (raw materials) up to retail. The stage of consumer and waste processing are not included (Blonk Consultants, 2020).

Dutch diet the Dutch diet can be defined as the commonly used kinds of foods the Dutch population habitually eats.

Greenhouse gas emissions (GHGE) GHGE signify emissions by gases that negatively influence the environment and therefore contribute to global climate change. These gases are: carbon dioxide, methane, nitrous oxide, and diverse halocarbons whereby carbon dioxide is the largest pollutant and halocarbons the smallest (Nolt, 2011).

IPCC-guidelines (2006) methodologies for making estimates of national anthropogenic emissions and removals of greenhouse gases.

ISO 14040 and 14044 guidelines ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). ISO 14040 and 14044 are the leading standards for Life Cycle Assessment (LCA). These international standards focus mainly on the process of performing an LCA.

Life Cycle Assessment (LCA) the LCA is a method that represents the life cycle of a certain product. All phases are analysed, from 'cradle' (raw materials) to 'grave' (end of the product chain, e.g. waste processing. By the use of this method, the environmental impact of each phase of a product is showed, and according to this certain 'hotspots' (those phases with the highest environmental impact) can be indicated. Besides greenhouse gas emissions (GHGE), also land use, water use, and acidification are taken into account (Blonk Consultants, 2020).

Prepit community in the Prepit community both followers of the Prepit Instagram account and users of Prepit@Home meals are included.

Prepit platform the 'Prepit platform' refers to the different channels Prepit is using to inform its users (i.e. Instagram, website, Facebook).

Pro-Environmental Behaviour (PEB) behaviour that is, in a particular society, seen as protective environmental behaviour or in support of a healthy environment (Krajhanzl, 2010).

Voedingscentrum the Voedingscentrum is a Dutch institution that offers reliable information on nutrition. It aims to help Dutch people in making more healthy, more sustainable, and safer food choices (Voedingscentrum, n.d.-a)

INTRODUCTION

Global warming is a hot topic today, and more and more people realise that the time to handle is now or never (Milfont, Wilson & Sibley, 2017; Fagan & Huang, 2019). One important determinant in the current climate debate is the role of our daily diet concerning CO2-emission. Approximately 20-30% of the CO2-emission derives from food and drinks (Tukker & Goldbohm et al., 2011). Though many people know that our diet contributes to environmental pollution, and even 42% of the adults agree that favouring a plant-based diet has quite a big effect on climate change, many of us cannot tell in what way or to what extent (Korkala, Hugg & Jaakkola, 2014). At the moment an increasing number of people are willing to change their diet for the good of the climate, but they struggle with finding conclusive and reliable information.

Prepit is an online platform, consisting of an Instagram and Facebook page, and a website, which aims to help consumers choose more sustainably by providing them with information on CO2-equivalent low ingredients and recipes. Prepit also has a meal service 'Prepit@Home', where customers can order a 'Prepit@Home' package which consists of a box with the ingredients for a CO2-eq low recipe.

This report aims to provide Prepit with tools and knowledge which can improve the current information provision and provide input to expand the platform. This report focuses on the following three main subjects, which both reflect the multidisciplinarity of the consultancy team as well as the interest of the commissioner. Firstly, an analysis and comparison of commonly consumed food products among Dutch people and the Prepit community is performed. Following this information, the different determinants of the CO2-eq output will be outlined and their respective influence on the total CO2-output of the commonly consumed food products. Secondly, information will be provided on the issue of behavioural change and sustainability which will result in several practical communication advises. The third and final subject will focus on the issue of CO2-eq reductionism and an alternative framework of analysis will be proposed which offers a more holistic view on the problem and relation between climate change and food. The main research question that has been formed goes as follows:

"What knowledge is needed for Prepit to contribute to reducing the CO2-eq emissions of the Dutch diet?"

The content of this report is based upon literature research, a survey and an analyses of 'the Dutch National Food Consumption Survey' and their respective CO2-eq output .

On the next page a list of all questions and sub questions is provided. The next three chapters aim to provide a question on the three sub questions. This will be followed with a conclusion and discussion section. Finally, an overview will be given with recommendations that can be used by Prepit.

1. What choices in fruits and vegetables can consumers make in order to contribute to a more sustainable diet?
    - What are commonly consumed food products in the Netherlands according to the Dutch National Food Consumption survey?
    - Which food products are commonly consumed among the Prepit community?
    - Which factors can be taken into account when estimating the average CO2-eq emissions of food products?
    - What is the average CO2-eq emission of several commonly consumed fruits and vegetables?
    - Which more sustainable options can replace commonly consumed vegetables and fruits with a high average CO2-eq emission?

2. What is needed in order to achieve behaviour change towards a more sustainable diet among Dutch consumers?
    - What theories and practices concerning behaviour change are applicable for changing to a more sustainable diet?
    - What are barriers for adapting a sustainable diet, experienced by consumers?
    - What are effective communication strategies in order to achieve behaviour change towards a more sustainable diet?
    - What advice is proposed when aiming to achieve behaviour change towards a more sustainable diet?

3. To what extent does CO2-eq emission reduction of food contribute to combating climate change?
    - Which factors, besides CO2-eq emissions, are important to take into account for calculating an ingredients environmental impact?
    - What are the consequences of reducing the problem on the environmental impact of food to only its CO2-eq emissions?
    - How can the complex issue of social and environmental impact of commonly consumed products be translated in a clear overview for consumers?

2. WHAT CHOICES IN FRUITS AND VEGETABLES CAN CONSUMERS MAKE IN ORDER TO CONTRIBUTE TO A MORE SUSTAINABLE DIET?

In order to answer this question, an analysis of the Dutch dietary pattern and an analysis of the dietary pattern of the Prepit community was performed. These dietary patterns were compared to see if there are any differences between their diets. This is visualized in the form of a list of commonly consumed food products by the Prepit community and the Dutch population of this project. Also, a summary of which choices in vegetables and fruits consumers can make towards a more sustainable diet was conducted. Besides, an overview is provided of the factors that can be taken into account when estimating the average CO2-eq emissions of food products. A special emphasis was put on the role of cultivation and greenhouse horticulture and its role in CO2 emission.

2.1 What are commonly consumed food products in the Netherlands according to the Dutch National Food Consumption survey?

An overview of the Dutch dietary pattern based on the results of the Dutch National Food Consumption Survey (DNFCS) 2012-2016 has been made and can be found in appendix A. The results of this analysis were compared with the results of the survey among the Prepit community. This comparison can be found in section 4.3.

2.2 Which food products are commonly consumed among the Prepit community?

A survey was conducted amongst the followers of Prepit. They were asked about their consumption at dinner and their total consumption of fruit and vegetables throughout the day. This survey was shared via Instagram and email to reach the followers of Prepit. However, it is important to consider the small amount of survey respondents when reading this chapter, as this may affect the reliability of some of the outcomes.

Literature on dietary assessment

The survey conducted amongst the followers of Prepit was a form of a dietary record. A dietary record turned out to be the most suitable form of dietary assessment for the purpose of this research (Thompson & Subar, 2017). A food frequency questionnaire provides little information on the characteristics of the food consumed, which makes it unsuitable for this survey. Typically, dietary records give an overview of the consumed food products over one or more days (Thompson & Subar, 2017). In an ideal situation, the recording would be done at the moment of consumption. However, it is expected that the response rate will be much lower when the survey cannot be filled in right away. It has been chosen to give the possibility to record the consumption both in household measures and grams. Choosing to record only one meal instead of an entire day might positively impact the accuracy, since the results can be of poorer quality when participants get tired. The intake of data is often collected in the form of open questions. The data processing can therefore be quite labor-intensive. The categories used in the survey are based on the categories of the nutrition guidelines of the Dutch nutrition center (Voedingscentrum, n.d.-a). A detailed overview of this survey can be found in appendix D. A short summary of the results per category will be provided in appendix C. What follows is more detailed information on the consumption of fruits and vegetables of the Prepit community and the comparison between the consumption of the Prepit community and the Dutch population.

Fruit

27 out of 28 respondents reported consumption of fruit. Apple is the most consumed fruit both by weight and frequency, followed by banana. Forest fruit and mandarin are in the top 5 of the most frequently consumed fruits, but not in the top 5 of the most consumed fruits by weight. Grapes and pear are in the top 5 of the most consumed fruits by weight, but not by frequency.

Vegetables

27 out of 28 respondents reported consumption of vegetables. Cucumber is the most consumed vegetable by weight. Tomato is the most consumed vegetable by frequency. Green salad and bell pepper are on the shared fourth place of most frequently consumed vegetables. Tomato, onion, cucumber and green salad are in the top 5 consumption both by weight and frequency. Green beans are in the top 5 of most consumed vegetables by weight, but not by frequency. Bell pepper is only in the top 5 of most consumed vegetables by frequency.

2.3 Comparison DNFCS: dinner of the Dutch population

The data used for the comparison with the Dutch population is the dataset of the DNFCS 2012-2016 of RIVM (Van Rossum et al,. (2018). For more detailed information about this dataset, see appendix A. However, the exact numbers from this dataset cannot be used for sharing, since these are confidential.

Since the data of the DNFCS is much more detailed than the data obtained from the Prepit survey, categories of consumed foods are made. For example, all potato products were combined in one category. In Excel, all relevant products for one category were added to show the total mean consumption by the Dutch population of a certain product category. The consumption data of the DNFCS is in mean grams per day. The data of the Prepit survey is the average consumption of products over all respondents. These two outcomes are compared. It is important to take the small sample size of the Prepit survey into account. Also, the data collection of the DNFCS was much more extensive. It is likely that the data of the Prepit survey entails more inaccuracies in the description and quantities of the food products consumed.

2.3.1 Results

Fruit

Table 1 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category fruit. The results show that the total mean fruit consumption of the respondents of the Prepit survey is nearly twice as high as of the Dutch population. For all fruit varieties mentioned in table X, the mean consumption is higher for the respondents of the Prepit survey. The orange was in the top 5 highest mean consumption by the Dutch population, but not in the top 5 by the respondents of the Prepit survey. Further, forest fruit was in the top 5 most frequently consumed fruits for the respondents of the Prepit survey, but not in the top 10 of the mean consumption by the Dutch population.

Table 1: Mean consumption fruit in g/day

Mean consumption fruit in g/day	Dutch population	Respondents Prepit survey
Fruit (total)	119	203
Apple	29.2	48.0
Banana	24.9	34.8
Grape	5.4	25.7
Strawberry	5.5	18.9
Pear	9.3	16.1
Mandarin	8.2	10.7

Vegetables

Table 2 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category vegetables. he results show that the total mean vegetable consumption of the respondents of the Prepit survey is more than twice as high as of the Dutch population. For all vegetable varieties mentioned in table X, the mean consumption is higher for the respondents of the Prepit survey. Broccoli was in the top 5 highest mean consumption by the Dutch population, but not in the top 5 by the respondents of the Prepit survey.

Table 2: Mean consumption vegetables in g/day

Mean consumption vegetables in g/day	Dutch population	Respondents Prepit survey
Vegetables (total)	131	287
Cucumber	8.4	65.4
Tomato	18	40.2
Carrot	9.2	24.5
Green salad	7.4	22.3
Green beans*	5.9	15.5
Unions	7.6	13.6
Sweet pepper	3.8	10.4

Fish/legumes/meat/meat replacers

Table 3 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category fish/legumes/meat/meat replacers. A few things stand out. The respondents of the Prepit survey reported a slightly higher consumption of legumes. Further, the mean consumption of meat replacers is much higher by the respondents of the Prepit survey. The mean consumption of egg and fish is somewhat higher by the respondents of the Prepit survey than by the Dutch population. Finally, a remarkable difference can be seen in the meat consumption: the mean meat consumption by the Dutch population is considerably higher than that of the respondents of the Prepit survey.

Table 3: Comparison mean consumption fish/legumes/meat/meat replacers in g/dinner

Mean consumption fish/legumes/meat/meat replacers in g/dinner	Dutch population	Respondents Prepit survey
Legumes (total)	3.5	6.4
Meat replacers (total)	1.3	32.3
Fish (total)	11.0	15.9
Eggs (total)	4.7	8.0
Meat (total)	61.0	38.6

Fats

Table 4 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category fats. The higher consumption of oils by the respondents of the Prepit survey stands out. Further, the respondents of the Prepit survey hardly reported the consumption of margarine, while margarine is a considerable part of the mean consumption by the Dutch population.

Table 4: Comparison mean consumption fats in g/dinner

Mean consumption fats in g/dinner	Dutch population	Respondents Prepit survey
Fats (total)	9.3	10.4
Oil	3.7	6.9
Butter	0.5	1.0
Margarine	1.9	0.1

Nuts and seeds

Table 5 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category nuts and seeds. The table shows the mean consumption of nuts and seeds is slightly higher for respondents of the Prepit survey. However, taken the low frequency of nuts and seeds consumption for the respondents of the Prepit survey into consideration, the difference is considered to be relatively small.

Table 5: Comparison mean consumption nuts/seeds in g/dinner

Mean consumption nuts and seeds in g/dinner	Dutch population	Respondents Prepit survey
Nuts and Seeds (total)	0.4	2.0

Dairy

Table 6 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category dairy. The mean consumption of dairy products by the Dutch population is more than twice as high as the mean consumption by respondents of the Prepit survey.

Table 6: Comparison mean consumption dairy in g/dinner

Mean consumption dairy products in g/dinner	Dutch population	Respondents Prepit survey
Dairy products (total)	77.3	34.8

Cheese

Table 7 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category cheese. Table X shows that the mean consumption of cheese is considerably higher for the respondents of the Prepit survey. The largest difference is found in the mean consumption of Parmesan cheese, of which the respondents of the Prepit survey recorded a consumption nearly 50 times as high as the mean consumption by the Dutch population.

Table 7: Comparison mean consumption cheese in g/dinner

Mean consumption cheese in g/dinner	Dutch population	Respondents Prepit survey
Cheese (total)	7.1	17.0
Parmesan cheese	0.2	9.5
Dutch cheese	3.3	2.1

Bread

Table 8 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category bread. The mean consumption by the Dutch population is slightly higher. However, taken the low frequency of bread consumption for the respondents of the Prepit survey into consideration, the difference is considered to be relatively small.

Table 8: Comparison mean consumption bread in g/dinner

Mean consumption bread in g/dinner	Dutch population	Respondents Prepit survey
Bread (total)	13.3	8.9

Cereal products/potatoes

Table 9 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the category cereal products and potatoes. The mean consumption by the Dutch population and the survey respondents is about the same as the mean consumption of the survey respondents. However, the pasta consumption of the survey respondents is slightly lower.

Table 9: Comparison mean consumption cereal products/potatoes in g/dinner

Mean consumption cereal products/potatoes in g/dinner	Dutch population	Respondent Prepit survey
Potato	65.6	70.4
Pasta	22.5	12.7
Rice	17.4	18.2

Other products

Table 10 shows the mean consumption by the Dutch population and by the respondents of the Prepit survey of the food products of the subcategories "dips and sauces" and coconut milk. The mean consumption of dips and sauces by the Dutch population is much higher. Further, the mean consumption of coconut milk is much higher for the respondents of the Prepit survey.

Table 10: Comparison mean consumption other products in g/dinner

Mean consumption other products in g/dinner	Dutch population	Respondents Prepit survey
Dips and sauces	23.5	4.4
Coconut milk	0.5	18.8

Other characteristics

Besides the questions regarding the ingredients of the meal consumed, a few additional questions were asked. First of all, figure 1 shows the percentage of meals that were vegetarian, and the percentage of meals containing meat and fish. It can be seen that a large majority of the meals was vegetarian.

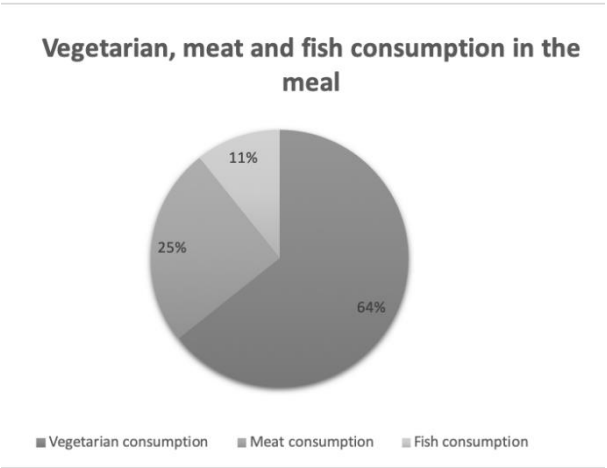


Figure 1: Percentage of vegetarian, meat and fish consumed in the dinner consumed by the respondents of the Prepit survey.

Secondly, figure 2 shows the age categories of the respondents of the Prepit survey. It can be seen that the large majority of the respondents is in the age category 18-25.

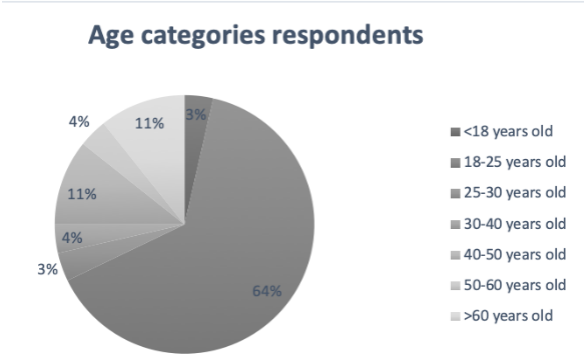


Figure 2: age categories of the respondents of the Prepit survey.

Lastly, the respondents were asked in which company the meal was consumed. The large majority was consumed with family/partner, followed by alone.

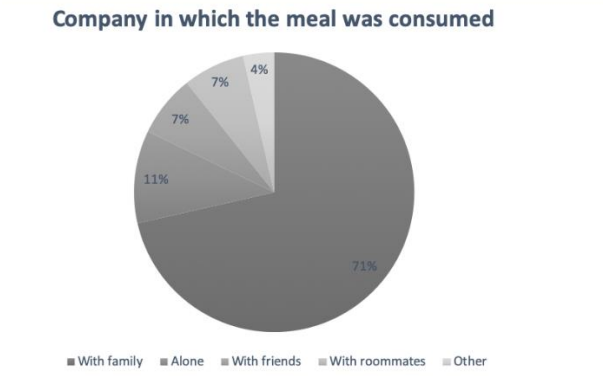


Figure 3: company in which the respondent of the Prepit survey consumed their dinner

2.3.2 Discussion

In the previous paragraphs, the food consumption during the meal in the evening and total fruit and vegetable consumption of the Prepit community have been described. However, there are some critical points which should be taken into account when interpreting these results.

Difficulties with estimation portion sizes

To start with, respondents have difficulties with estimating portion sizes. For example, one respondent described having consumed six serving spoons of potatoes during the meal in the evening, while a normal portion of potatoes consists of approximately 200 grams (2.5 to 3 serving spoons). Another respondent reported to have eaten 100 grams of Parmesan cheese on his or her pasta, although a normal portion of Parmesan cheese is approximately 10 grams according to the Eetmeter (Voedingscentrum, 2020). This may have affected the results, because these products may seem to have been eaten in in larger or smaller quantities, even though they were not. Due to a relatively small sample size, this has a large effect on the outcomes. In the case of the RIVM and their DNFCS, this is not the case since the research was executed very accurately, next to the larger sample size.

Not all eaten ingredients have been filled in

Secondly, it is expected that not all respondents filled in all the ingredients they have eaten. As an illustration, one respondent reported that he or she consumed pancakes without any kind of topping. There is a plausible chance that the respondent has forgotten to mention these. This reduces the reliability of the results, since these products are not included in the analysis in this way.

Selection bias

Thirdly, it is expected that the people who completed the survey, are also the people who are most involved in Prepit and most interested in sustainability. So, the outcomes of this survey may not represent the entire Prepit community, resulting in a selection bias.

Small sample size

Furthermore, due to the small sample size and the fact that only the consumption of one day has been questioned, the results may be less reliable as it does not reflect an average evening dinner of all members of the Prepit community. On top of that, not all respondents understood all questions well. For example, the respondents were asked to fill in the fats they used in the meal (to prepare the food). However, one respondent thought that this question was about fatty products that were in the meal, for example cheese. This makes the answers of some respondents not accurate, which in turn affects the sample size and thus the reliability of the results. Lastly, the first time the survey was shared was on a Friday, so the respondents would report what they consumed on Thursday. However, the second time the survey was shared was on a Monday. In this case, respondents filled in what they ate on Sunday. The food consumption in the weekend is expected to differ from the food consumption during the week (Monteiro et al., 2017). This may have influenced the results, since this makes it more difficult to make a comparison.

Besides gathering information about the food consumption of the Prepit community, some general questions have been asked as well. To begin with, the age category was asked for example. The majority of the respondents were in the age group of 18-25 years old (64%). This is in line with the followers of Prepit's Instagram page, since most of the followers of this page are also in this age category. A difference between the respondents of the survey and the followers of Prepit's Instagram page, is that there are more older respondents. For example, three of the survey respondents are over 60 years old and four respondents are between 40 and 60 years old. It is expected that this difference is caused by the fact that social media is particularly popular among young people (Lenhart, 2015). In addition, the users of the Prepit@Home service were approached for this survey as well. It is assumed that people who use a meal service are people who live on their own and cook for themselves, and are therefore older. It may be useful for Prepit to take these older people into account as well, for example by offering recipes that appeal to this age group (e.g. typical Dutch meals as "stamppot"). Secondly, a question has been asked whether the respondents had eaten alone, with family members or roommates. It has been found that most respondents have consumed their meal in the company of their family or partner (71%). This was not in line with what was expected as the majority of the respondents is in the age category of 18-25. It was expected that many people in this age category are students and therefore may live on their own. This does not appear to be the case. Only 11% of the respondents reported to have consumed their meal alone. Prepit could respond to this by mainly focusing on recipes suitable for more than one person or by asking with how many people the meal will be consumed in order to avoid food waste. Lastly, it has been researched whether the Prepit community mainly eats meat, fish or vegetarian. It has been found that the majority of the people consumed a

vegetarian meal (64%). On top of that, 4 respondents even consumed a vegan meal. This matches the expectations, as it is assumed that people interested in sustainability (Prepit community) are more willing to prepare a vegetarian meal. Prepit can take this into account by offering mainly vegetarian recipes. It is remarkable that the cheese consumption of the Prepit community is much higher than of the Dutch population. This could be due to the high amount of vegetarian meals consumed, since cheese is often used as a meat replacer.

2.3.3 Recommendations for Prepit

Based on the comparison described in the previous paragraphs, there are a number of recommendations for Prepit to make its community eat even more sustainably. To begin with, it has been found that the Prepit community consumes on average more than twice as little dairy as the average Dutch consumer. However, to achieve diet lower in CO2-eq emissions, it may be useful for Prepit to promote the use of plant-based alternatives for milk and cream, since these are products that are still regularly used by the Prepit community. Examples of such alternatives could be the use of plant-based milk (e.g. soy milk, oat milk, almond milk) or the use of cuisine soya, haver cuisine fraiche to make recipes creamier. Secondly, the Prepit community consumes significantly more meat substitutes compared to the average Dutch consumer. It would therefore be interesting for Prepit to delve into sustainable meat substitutes and vegetable protein sources (for example, as mentioned in sub question 2, peas, nuts, peanuts, and beans), because these kind of products are widely consumed among Prepit's audience. An example of a good plant-based protein source would be the use of legumes, since they are very suitable protein sources. Another remarkable difference between the average Dutch consumer and the Prepit community is the cheese consumption. The Prepit community consumes considerably more cheese, especially Parmesan cheese. It would be good if Prepit would focus on this by promoting the use of more sustainable alternatives to cheese in its recipes. Examples could be younger and softer cheeses (e.g. hüttenkäse or mozzarella) or the use of nutritional yeast (Milieucentraal, n.d.-a). Another good option would be to replace the cheese with nuts, because the Prepit community does not consume a high quantity of nuts yet. Nuts contain high amounts of unsaturated fats, making them very creamy and tasteful.

2.4 Which factors can be taken into account when estimating the average CO2-eq emissions of food products?

In order to answer sub question 1c, the following factors are elaborated on to be able to estimate the CO2-eq emissions of food products: 1) cultivation (greenhouse cultivation vs open ground); 2) seasonality; 3) storage; 4) transport; and 5) packaging. For each of these factors it is described what is involved and how it links to CO2-eq emissions.

Greenhouse horticulture and open ground

In order to cultivate fruits and vegetables, a distinction can be made between greenhouse horticulture and open ground cultivation. The former one is responsible for approximately a quarter of the CO2 emissions released in the agriculture sector in the Netherlands (RVO, 2016). This is mostly due to the high use of natural gases needed to heat the greenhouses. Open ground cultivation, including grass, causes 20% of the CO2-eq emissions of agriculture in the Netherlands, which is mostly attributable to fertilizers and manure. In open ground cultivation, the energy consumption plays only a small role (RVO, 2016). In the Netherlands, 20% of the available vegetables originate from open ground, 66% from greenhouse horticulture, and the remaining 14% vegetables are imported (Voedingscentrum, n.d.-b). Such clear percentages are not available for fruits, but according to Voedingscentrum (n.d.-c) most fruit cultivated in the Netherlands comes from the open ground. In the following paragraphs, these two different methods will be further elaborated on.

> *"In the Netherlands, 20% of the available vegetables originate from open ground, 66% from greenhouse horticulture, and the remaining 14% vegetables are imported"*

Greenhouse horticulture implies using a glass roof and walls of glass to protect plants against cold and wind (Voedingscentrum, n.d.-b). Besides, warmth and light are continually regulated in a way that plants can grow optimally. According to W. Verkerke, this is one of the main advantages of greenhouse horticulture (personal communication, June 18, 2020). Greenhouse horticulture is controllable, which means that it is possible to produce exactly what the consumer needs and wants. On top of that, this controllability reduces land- and pesticide use (personal communication, June 18, 2020). Often in greenhouses, rock wool is used instead of using soil. The biggest advantage of using rock wool, is that this material has a high degree of sterility (Bussell & McKennie, 2004). Because of the sterility, potential

diseases, pests, and weed seeds can be prevented. Also, rock wool is efficient; more than 98% of added water or fertilisers is immediately available for uptake by the crops. A disadvantage of using rock wool is that it is difficult to use it more than once (Bussell & McKennie, 2004). Another characteristic of greenhouse horticulture is that via certain drippers, crops and plants are administered water with nutrients to grow, which is computer controlled. In this way, crops are able to grow faster when compared to open ground and increases the efficient use of water and fertilizers (Bussel & McKennie, 2004; E. Poot, personal communication, June 19, 2020). Another advantage of greenhouse horticulture concerns resistance against our changing climate, crops are better protected against extreme weather (E. Poot, personal communication, June 19, 2020). It has been found by the Voedingscentrum (n.d.-b) that the following vegetables are regularly grown in greenhouses: tomatoes, cucumbers, peppers, broccoli, eggplant, zucchini, radich. Some of this information is debatable however, as Poot (personal communication, June 19, 2020) argues that broccoli is often grown in open ground. Fruits that are often cultivated in greenhouses are strawberries, outside the summer season, and kiwi's (Voedingscentrum, n.d.-b). Besides fruits and vegetables, also flowers are grown regularly in greenhouses.

The downside of greenhouse horticulture, as stated before, is that it costs a high amount of energy because of the heat and light regulations it needs. This is in line with the outcomes of the interview with W. Verkerke (personal communication, June 18, 2020), who mentioned that the most important disadvantages of greenhouses are its energy use and its light pollution. Light pollution is the presence of unwanted and excessive light, which is a form of waste energy. It can cause adverse effects which can degrade the environmental quality (Britannica, n.d.). However, from 1990 the CO2 emissions from greenhouse horticulture has decreased with 16% and since 2014 the CO2 emissions are stabilized. This is due to extensification, energy savings, green energy, a bigger sale of electricity, and a smaller area of greenhouses (in hectares) (Wageningen University and Research, n.d.). Furthermore, the Dutch greenhouse horticulture sector aims to reach a completely sustainable energy supply by 2050 (Milieucentraal, n.d.-b). Therefore, the sector focuses on energy savings, geothermal heat, and cogeneration (Milieucentraal, n.d.-b; Government of the Netherlands, n.d.). Geothermal heat is characterized by the use of normal ground or groundwater temperatures. The required electricity input hereby is low; the energy output is four times as high as the input (Lund, Sanner, Rybach & Curtis, 2004). Cogeneration uses warmth and electricity more efficiently, which results in a lower demand for natural gasses. Because of both cogeneration and geothermal heat, products originating from a cogeneration glass house release lower CO2 emissions. However, unfortunately this cannot be tracked down for products in the supermarket (Milieucentraal, n.d.-b). Currently also research is being done in order to develop circular greenhouses. The aim of circular greenhouses is to become CO2-neutral, reuse water, and prevent fertilizer and pesticides from infecting groundwater (Glastuinbouw Nederland, n.d.). Both greenhouse experts Poot and Verkerke (personal communication, June 19, 2020; personal communication, June 18, 2020) expect that these ideas have potential for making greenhouse horticulture sustainable.

> *"The most important disadvantages of greenhouses are its energy use and its light pollution."*

The other method to grow crops, so-called open ground cultivation, does not consume energy like the previously described method which lowers its total CO2 emissions. Within open ground cultivation, fertilizer use is the biggest contributor to CO2 emissions, accountable for 34,4% (Broekema & Blonk, 2010b). Also, diesel use, straw, and packages play important roles in the amount of CO2 emissions. Fruits that are often cultivated in open ground, are raspberries, berries, and blackberries. In addition, strawberries are occasionally grown on open ground. Also, the Netherlands has multiple orchards, especially in the 'Betuwe', where among others apples, pears, plums and cherries are grown (Voedingscentrum, n.d.-c). It is difficult for consumers to find out whether their vegetables and fruits have been grown in greenhouses or in open ground. As mentioned in the former paragraph, there are a variety of crops of which their general production method is known (Poot, personal communication, June 19, 2020). This struggle also came forward in the interview with R. Helmes, where he stated that consumers are often confronted with a lack of transparency with regard to the cultivation method of a certain food product (personal communication, June 4, 2020). For the outcomes of the interview with R. Helmes, please refer to Appendix B.

To emphasize the differences in the two methods with regard to CO2 emissions, three examples of fruits and vegetables will be further elaborated. For an overview of these examples and their corresponding

CO2-eq emissions, please refer to table 11. The first example is the crop spinach, which can be cultivated on both greenhouse horticulture and open ground. According to Broekema & Blonk (2010a), the CO2eq/kg of fresh spinach grown in greenhouse horticulture is approximately 3, which includes CO2 emissions released by transport, consumer, supermarket, distribution, processing, and cultivation. Hereby, the use of natural gasses covers 61% of the total CO2 emission. In comparison, fresh spinach cultivated on an open ground, has a CO2eq/kg of circa 1. This reduction in CO2 emissions is mostly due to the different cultivation method (open ground), while the other factors remain the same. The second crop that will be used as an example for comparison is green beans. Green beans grown in greenhouses located in the Netherlands have a CO2eq/kg of approximately 3.2. However, if green beans are grown on open ground, this CO2eq/kg is only 0.65 (Broekema & Blonk, 2010a). The third example that will be used to illustrate the two different methods, is strawberries. In strawberries, the difference in CO2-eq between greenhouse horticulture (4.6) and open ground cultivation (0.5) is remarkably high. The amount of CO2 emissions for a ton of strawberries in the open ground is 10% of the CO2 emissions released in greenhouse horticulture for a ton of strawberries, while the yield from greenhouse horticulture is almost eight times as high as the yield from open ground. This is mainly attributable to the substrate on which strawberries grow in greenhouse horticulture, the materials used, and the use of natural gasses (Broekema & Blonk, 2010b).

"The amount of CO2 emissions for a ton of strawberries in the open ground is 10% of the CO2 emissions released in greenhouse horticulture for a ton of strawberries"

A new useful tool for Prepit could be the PEF (Product Environmental Footprint) calculator, which will be published on the first of July in 2020. It is not clear yet whether this calculator will be usable for personal use, or whether it will only be possible to work with the results of other parties. According to W. Verkerke, this calculator makes use of eight dimensions of sustainability, which can be assessed separately to determine the sustainability of a (food) product. These are the following dimensions: acidification, global warming, eutrophication, photochemical potential, abiotic potential, CO2, water consumption and land use. This tool has already been tested for some tropical fruits and its sustainability has been determined for different delivery methods (e.g. grown in the Netherlands and then transported by a truck, grown in country of origin and then transported by plane or grown in country of origin and then transported by boat). The big advantage of this tool is that it allows PEF calculations to be comparable between products of the same product category (personal communication, June 18, 2020).

Unfortunately, in this phase of the food supply chain, which is called primary production, food waste and food loss take place. Food waste stands for 'the decrease in the quantity or quality of food resulting from decisions and actions by retailers, food service providers and consumers' (FAO, 2020). Food loss refers to this same decrease in quantity or quality of food, but then resulting from food suppliers in the chain, and not taking retailers, food service providers and consumers into account (FAO, 2020). However, it remains difficult to quantify the amount of food waste and losses in this phase since it has not been researched as much as other stages of the food supply chain (Stenmarck et al., 2016). The main explanation for this is its variety in the produced products, and the corresponding diverse waste levels. Besides, it is hard to classify food waste earlier in the food supply chain when there has to be dealt with unprocessed food products such as crops (Stenmarck et al., 2016). Despite the experienced difficulties in the amount of food waste in this stage, an estimate is made. Approximately, in Europe, one-third of all food waste is generated in the stage of primary production (Bräutigam, Jörissen & Priefer, 2014; Priefer, Jörisson & Bräutigam, 2013). Fruits and vegetables have the largest share in this (Gustavsson, Cederberg, Sonesson, Van Otterdijk & Meybeyck, 2011). Furthermore, in the primary production stage factors such as pest/disease management and choice of crop variety also affect food losses in the post-harvest stage (Daviron, Nango Dembele, Murphy & Rashid, 2011).

In conclusion, fruits and vegetables cultivated in open ground are generally lower in CO2 emissions than fruits and vegetables originated from greenhouse horticulture. For an overview of the different CO2-equivalents for various types of fruits and vegetables, please refer to table 9. Despite the high energy use of greenhouse horticulture, efforts are being made to reduce its emissions by making use of cogeneration. However, in the supermarkets it is not (yet) clear which products originate from cogenerating greenhouses, which makes it hard for the sustainable consumer to consciously choose these products. Finally, another identified problem within the primary production stage are the high numbers of food waste.

Table 11: CO2-eq of spinach, green beans, and strawberries divided in greenhouse horticulture and open ground cultivation (Broekema & Blonk, 2010a/b).

	Greenhouse horticulture	Open ground
Spinach	3 CO2-eq/kg	1 CO2-eq/kg
Green beans	3.2 CO2-eq/kg	0.65 CO2-eq/kg
Strawberries	4.6 CO2-eq/kg	0.5 CO2-eq/kg

Seasonality of fruits and vegetables in the Netherlands

Products that are harvested and sold in a certain period, are considered seasonal products (Voedingscentrum, n.d.-d). Brooks, Foster, Holmes & Wiltshire (2011) argued that consumers generally believe that environmental impact is mainly impacted by the distance of transportation, while a large share also comes from production methods (e.g. heating greenhouses).

Vegetables that are generally considered most sustainable, are those coming from the open ground (seasonal vegetables) or from a relatively sustainable greenhouse (one that requires only little warming) (Voedingscentrum, n.d.-e), as explained in the previous section. Vegetables that are also stated to be relatively sustainable, are vegetables originating from Europe. There are several vegetables that are relatively sustainable all year long, also when they originate from a different country than the Netherlands. Products that are sustainable all year long are for example broccoli, cauliflower, lettuce, beetroot, onion, tomatoes, red and white cabbage, and carrots (Voedingscentrum, n.d.-e).

The same accounts for fruits: many fruits can be obtained relatively sustainably during the whole year, even when they are produced in another (nearby) country. There are, however, firm fruits that are transported from countries further away, such as bananas, citrus fruits, and grapes. Although they are originally from far-away countries, their environmental impact is reasonable, since these are transported in great quantities by boat (from tropical countries) or by truck (from the South of Europe). There are several fruits that are considered sustainable all year round, and are also consumed in large quantities by the Dutch population, which are for example: apples, bananas, grapes, kiwis, pear and tangerines. Soft fruits, such as strawberries, are most sustainable when produced and sold during summer. Before summer, at the beginning of spring, strawberries are grown in greenhouses (Voedingscentrum, n.d.-e). Soft fruits are, however, generally vulnerable and are more prone to food loss compared to other fruits (De Valk, Hollander,&Zijp,2016). Additionally, energy is spared when fruits and vegetables are grown on the field in the South of Europe, since sunlight and temperature are often favourable for the production of these food products. However, it is often more dry in these areas, which means extra water is sometimes needed (Voedingscentrum, n.d.-d).

Then, is it better to eat a food product that is coming from the South of Europe than a product that is not in season, but still produced within the Netherlands? Food that is harvested in a country far away, but in season, can have a lower CO2 equivalent compared to foods harvested locally, but out of season (Brooks, Foster, Holmes, & Wiltshire, 2011). When fruits and vegetables – not in season – are harvested in greenhouses, generally a lot of energy is needed for the provision of warmth and light. This is for example the case for bell peppers. This shows that going for the local option is not always the best option when looking at the CO2-eq from the production of vegetables (Röös & Karlsson, 2013). However, there are exceptions on food products harvested in greenhouses. Tomatoes and cucumbers harvested in greenhouses can sometimes be quite sustainable, when these are produced in more sustainable greenhouses that use relatively little energy, and because they have high yields (Voedingscentrum, n.d.-d). Besides, because of the electricity production system in the Netherlands, it is more efficient to grow tomatoes all year round in greenhouses, than it would be to not produce vegetables in winter time, in order to stick to natural growing seasons (Röös & Karlsson, 2013).

> *"Food that is harvested in a country far away, but in season, can have a lower CO2 equivalent compared to foods harvested locally, but out of season"*

Furthermore, there are also many fruits and vegetables that originate from fields in South-America, Africa or New Zealand, for example. These are sometimes transported by plane, which makes it unsustainable. However, bananas growing in these areas generally have low CO2 emissions. Production of bananas requires low levels of energy and water, and these products are mostly transported in large quantities by boat (Voedingscentrum, n.d.-d). Most of our fresh produce come from within the EU and as such are unlikely to travel by air, and considerably

more likely to be transported by road or by sea (Garnett, 2006). The role of transportation in the total CO2-eq emissions of food product will be later discussed in this chapter.

In what follows, several examples of generally sustainable options of vegetables are mentioned per season, defined by Voedingscentrum. In summer (July, August and September), zucchini, (fresh) peas, fennel, and spinach are considered seasonal. In order to consume sustainable vegetables in autumn (October, November, December), pumpkin, parsnip, bok choy, and celeriac are generally a good option. Vegetables that are considered a sustainable option in wintertime (January, February, March), are kale, swede, and, similar to autumn, pumpkin and parsnip. In spring, asparagus, cucumber, different kinds of tomatoes, and broad beans can be eaten sustainably (Voedingscentrum, n.d.-d).

In conclusion, it can be stated that, generally, open ground production is linked to seasonality, and would be the option with the lowest CO2-eq/kg. However, it should be noted that open ground production entails other negative side issues. For example, during the process of open ground harvesting of strawberries, low levels of CO-eq/kg are observed, while high levels of acidification, water depletion and eutrophication are involved (De Valk, Hollander, & Zijp, 2016). Besides, it might be more sustainable to get fruits and vegetables from another (European) country where they are in season, than to choose locally, when these foods are harvested in greenhouses off-season. This might be something consumers do not always realise and this could be emphasised in promotion of sustainable eating by Prepit. Besides, as stated before, Voedingscentrum is providing Dutch people with examples of sustainable fruits and vegetables per season, which can also be used to promote sustainable consumption. However, it should also be acknowledged here that, when looking at the whole food sector, eating seasonal fruits and vegetables has a relatively low impact on reducing the total CO2-eq of food (Röös & Karlsson, 2013).
Lastly, some concrete recommendations are provided on sustainability for certain fruits and vegetables (Figure 3).

Storage
Storage of fruit is different for every type of fruit. In order to preserve its quality, it is important to cool the product and continue to cool it during all stages from harvest to food outlets, which contributes to the CO2-eq. Fruits that are grown in tropical circumstances should be cooled down to its optimum storage temperature as soon as possible (Montero-Calderón & Cerdas-Araya, 2012). Precooling lowers the rate of occurrence of several metabolic reactions and it prevents fruit from deterioration. In the process of storage, besides temperature, also O2 and CO2 rates play a role. For example, for bananas, the optimal storage conditions would be a temperature of 12-16°C, 2-5 O2, and 2-5 CO2 (Montero-Calderón & Cerdas-Araya, 2012). While bananas can be stored for a maximum time of three weeks, apples can be stored up to 26 months, and are recommended to be stored

BELL PEPPER

Most bell peppers available in Dutch supermarkets, are grown in Dutch greenhouses. The sustainability of bell peppers largely depends on the type of greenhouse. There are greenhouses that use geothermal energy, which are considered more sustainable. Greenhouses heated with gas use considerably more energy. Unfortunately, as a consumer, you don't have insight into the kind of greenhouse your bell pepper is coming from. Supermarkets have more power in this, by being able to select bell peppers coming from certain greenhouses.

GREEN BEANS

Green beans are grown in open fields from July to September in the Netherlands. In other months during the year, green beans come from far-off countries. Many fine green beans (haricots verts) are from Kenya and are transported by plane. Regular green beans are mostly shipped from Morocco, Senegal or Egypt. Alternatively, frozen green beans can be consumed. Their environmental impact is slightly impacted because of the method of freezing, but are more sustainable than beans flown into the Netherlands.

STRAWBERRIES

In the Netherlands, strawberries that are grown in open fields, are sold from June to September. Outside this timeframe, strawberries are harvested in Dutch greenhouses, or in Spain. This causes the strawberries to be less sustainable because of energy used in greenhouses, or transport from a different country. It would therefore be better to consume strawberries during the period from June to September.

at 0-4°C(Bhat, 2012). Besides fruits, also vegetables are stored refrigerated. For instance, the optimal temperature for tomatoes to be stored in is 12°C, and for lettuce and spinach the optimal temperature is 0°C (Raju, Chauhan, & Bawa, 2010).

The storage process of apples in Italy (from harvest to right after packaging) is explored in the study by Boschiero, Zanotelli, Ciarapica, Fadanelli, & Tagliavini (2019). The apples are pre-cooled after picking, where a screw compressor is used to produce ammonia. Then, refrigeration takes place in storage cells, where glycol recirculation keeps apples at the temperature of 4°C. After this, the phase of conservation takes place. Here, apples are kept in a controlled atmosphere that serves to limit metabolism of the apples. There are three techniques that can be used: CA (controlled atmosphere), ULO (ultra-low oxygen), and DCA (dynamic controlled atmosphere). DCA has shown to be substantially higher in its environmental impact compared to the other two techniques, because DCA has a higher electricity demand. Almost a third of all apples are stored using the ULO technique. About half of the apples are selected for direct packaging, whereas the other half needs longer refrigerated storage (up to one month) due to their size and quality.
Refrigerated storage and packaging of the apples both

> *"It can be concluded that refrigerated storage relatively largely contributes to CO2-eq emissions in the process of storage"*

mainly contribute to the CO2-eq and energy requirements in the process of storage (Boschiero, Zanotelli, Ciarapica, Fadanelli, & Tagliavini, 2019).
Also, storing fruits and vegetables in supermarkets contributes to CO2 emission. Some fruits and vegetables require refrigerated storage. Refrigerated storage contributes up to 50% of the total energy consumption of supermarkets (Van Gerwen, 2020). By this, the climate is impacted. The refrigerant that was widely used, is called R404A (HFK) which generally has a higher environmental impact. However, supermarkets are switching more and more towards natural refrigerants that have lower levels of energy consumption, such as ammonia, CO2, and isobutane and propane (Van Gerwen, 2020).

All in all, storage is different for every type of fruit or vegetable. It can be concluded that refrigerated storage relatively largely contributes to CO2-eq emissions in the process of storage. This kind of storage takes place after harvesting, and in the retail process in supermarkets.

CO2 emissions of transportation of food (fruits and vegetables)
Fruits and vegetables often have travelled a long way before they reach the plate of the consumer, this distance is indicated by food miles. 'Food miles' is a term that indicates the distance that a food product has travelled from the producer to the consumer (Paxton, 1994). In 2019, the export of fruits and vegetables from the Netherlands valued 6.2 and 7.3 billion euros respectively (Jukema, Ramaekers & Berkhout, 2020). Furthermore, 6.5 billion euros worth of fruit and 2.7 billion euros worth of vegetables were imported in 2019 (Jukema et al., 2020). In 2018, around 40% of the Dutch exported fruits and vegetables were cultivated in the Netherlands. For the fruits and vegetables that were imported in the Netherlands, less than 20% were intended for the domestic market. The remaining 80% were further transported around the globe (Fruit & Vegetables Facts, 2018). This illustrates how much food is transported all around the globe and travels to and from the Netherlands. But, as mentioned earlier, eating locally is not always the answer either. According to an article from Ritchie (2020), transportation accounts for less than 10% of the total GHG emissions derived from food. She argues that this only plays a minor role and it should not be the main focus when trying to reduce the environmental impact of our food. Boye & Arcand (2012) argue that transportation is important, but when taking the full LCA into account the transportation of our food does not have the largest environmental impact.

On the other hand, for fruits and vegetables specifically, food transportation may account for 50% of the total CO2 emissions (Weber & Matthews, 2008). It turns out that GHG emissions that result from transportation are overall relatively low for products like meat, but high for fruits and vegetables. As the production of meat has a great impact on the environment, high GHG emissions as a result of land use change and farm processes, the share that transportation contributes to the total GHG emissions is relatively low. As for fruits and vegetables less GHG emissions are released during production, transportation plays a relatively bigger role.

As described earlier, fruits and vegetables imported from another country can sometimes have a smaller CO2-eq emission than the same fruits and vegetables locally grown. There are different modes of transportation for food, and emission factors for these modes of transport vary among studies. The

following CO2-eq emissions have been identified for each mode of transportation (Weber & Matthews, 2008; Poore & Nemecek, 2018). The emissions are expressed in kg CO2eq per ton-km. Ton-km is defined as the movement of 1 metric ton of cargo over 1 km.

The emission numbers from Weber & Matthews (2008) for transport via rail and truck depends on the type of fuel (for both rail and truck) and the size and type of truck used. The emission numbers for transport via air already include radiative forcing. Radiative forcing is defined as "the net change in the energy balance of the Earth system due to some imposed perturbation" (Myhre et al., 2013, p.664). It is used as a quantitative measure to compare the change in the global mean temperature to different perturbations. In this case, the perturbation is transport by airplane. It is not clear whether radiative forcing has also already been included in the emission numbers from Poore & Nemecek (2018). A distinction was made between transporting food under ambient or temperature controlled circumstances.

From table 12, it can be concluded that food transportation via air has the greatest kg CO2-eq per ton-km. However, only 0.16% of the global food miles is from transport via air. In contrast, 58.97% of our food is transported by water, 30.97% by road and 9.9% by railways (Poore & Nemecek, 2018). Furthermore, the concept of food miles is not flawless. Food miles only give an impression of the distance a certain food product has traveled, but it does not take other environmental factors into account (Schnell, 2013). Ballingall & Winchester (2010) argue that campaigns that focus solely on food miles will only increase global inequality and might not even lead to an improvement in environmental outcomes.

In summary, a lot of food is daily transported around the globe. It is estimated that food transportation for fruits and vegetables account for 50% of the total CO2 emissions. Although food transportation by plane shows the highest kg CO2-eq per ton-km, only a small amount of global food miles is from transport by plane. Most food is shipped by water and land transport. What should be taken into account is that transportation has a relatively low impact (less than 10%) on total GHG emissions coming from food, which implies that a focus on (only) transportation would not be recommended.

Packaging

It is also important to consider the role of packaging in the LCA of a product when determining the CO2-eq. However, evaluating the impact of packaging in terms of CO2 emission is a complex phenomenon. To make a proper analysis you need to consider amongst others, the production of the material, transport of the material, the potential recycling of the material (in terms of energy saved/used by performing the recycling), the energy saved by preventing food loss, and the difference in the nutritional value of the same product in different packages. These factors are all strictly connected to environmental issues and therefore packing on average takes 10% of the total environmental impact of a product (Ingarao et al, 2016).

First, the production of materials has a significant environmental impact, it causes approximately 20% of the global CO2 emissions and consumes about 21% of the global energy demand (Ingarao et al, 2016). Several materials are involved in packaging, in the EU the most commonly used materials are paper, board, glass, plastic, wood, and metal (steel and aluminum). A study performed by Igarao et al (2016) estimated the greenhouse gas emissions associated with the key steps in the supply chain for tin steel can (TS), Glass (GL), and Polypropylene (PP) (see figure 2).

Table 12: Comparison CO2-eq emissions transportation

Mode of transportation	*Weber and Matthews (2008)* Kg CO2-eq per ton-km	*Poore & Nemecek (2018)* ambient temperature kg of CO2-eq per ton-km	*Poore & Nemecek (2018)* regulated temperature kg of CO2-eq per ton-km
International water-container	0.14	0.01*	0.02*
Inland water	0.21	0.01*	0.02*
Rail	0.18	0.05	0.06
Truck	1.8	0.2	0.2-0.66
Air	6.8	1.13	1.13

These steps include raw materials extraction, primary production of the packaging material, package shaping, recycling, and final waste disposal.

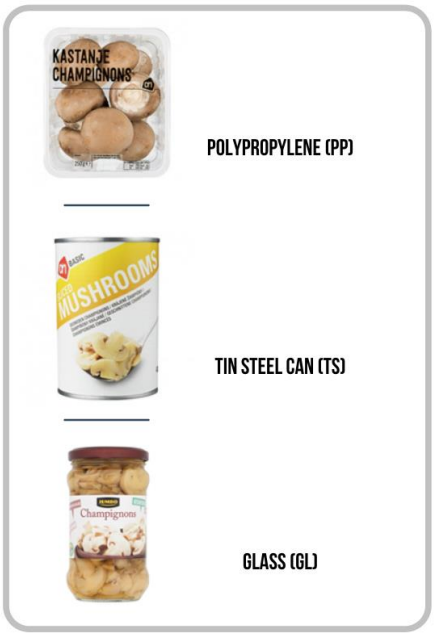


Figure 4: Packaging PP, TS, GL

According to this study, the plastic option is the greenest and the glass option is the worst, assuming that the glass is not reused in its original state. This is due to the weight of the plastic packaging compared to the glass and can package. It should be mentioned that this study is performed in Italy and therefore Italian methods of recycling and production are used. Based on data provided by EEA singular report on Municipal Waste Management (EEA 2014) the Netherlands is scoring a bit better on the recycling targets in comparison to Italy. Nevertheless, the precise difference in production and recycling per product is difficult to map for different countries. However, other studies are showing similar results, e.g. recent carbon footprint analyses done for a packaging manufacturer show that from a carbon emissions standpoint, plastic is often a better material for the production of bottles (Wakeland, 2012). Also, some research has been performed on wine bottles compared to PET-bottles, considering their full life cycle, a 360 mL PET bottle generates 41% fewer greenhouse gas emissions than a comparable glass bottle (Constar, 2010).

On the other hand, a Dutch study performed by Broekema en Blonk (2010) shows that the use of can or glass in comparison to the use of plastic is minimal. This report, furthermore, suggests that the horticulture cultivation or open ground cultivation is more important than the packaging material. Overall, fresh products from open fields in the Netherlands are always the best option. Note that this is not taking food loss into account. Furthermore, in some cases like for spinach, which shrinks to a great extent during cooking, it can be more efficient to buy a frozen/packaged version. Fresh spinach takes up more space, and therefore more packaging material is needed.

Another report by Plumers et al (2011) evaluated the uses of package material of drinks and the impact on the environment. They evaluated the differences in CO2-eg/l for 1.5 L PET-bottle with a deposit, a can (0,33L), and a single-use 0.5L PET bottle. Respectively, the contribution to GHG-emission for these products was 22%, 33%, and 35%. Furthermore, their results show that a single-use glass bottle (without deposit) has a 6 times larger environmental impact compared to paper package (Plumers et al, 2011).

Also, different types of packaging material may differ in terms of the amount of transport post-filling. Use of heavy glass versus lighter plastic bottles for a given volume of product will, for example, give differences in total transport ton-km. If transport is weight-limited, it may well be that glass bottles mean a lower volume load factor and therefore more trips for a given volume of product.

However the contribution of packaging to GHG emission can be reduced when packaging is (partly) recycled. Recycling e.g. glass-packaging, can reduce the GHG emission of packaging with 30-40%. In the case of green beans, this results in a decrease of 13% GHG emission when consuming beans in glass (Broekema & Blonk, 2010a). The Netherlands is one of the leading European countries in glass recycling and each year about 80% of used glass is returned to the manufacturing process (van de Wiel, 2015).

In addition, the nutritional value of products is important to consider in the evaluation of the sustainability of a packaged product (Röös et al, 2015). Nutritional value can change due to conserving, preparing (e.g cutting and cleaning), and storage. All these factors contribute to a greater or lesser extent to degradation in nutritional value. Though, this nutrient loss variates between products, overall count that when the product is consumed that packaged versions almost meet the same nutritional value as the fresh products. This is due to the short time between harvest and packaging, whereby the loss of quality of the packaged product is minimal (Broekema & Blonk, 2010a). Considering this, the nutritional value is equally distributed and can be omitted in the comparison of the different packaging materials.

On the other hand, for a number of types of packaging the prevention of product spoilage and discard has greater environmental benefits than the negative impact of the packaging in question. In the case of perishable goods with a major environmental

footprint, such as greenhouse vegetables and fruits, is (far) more important for the environment than the impact of the packaging. A study based on Swiss data has recently found that for plant-based products, avoidable losses in food waste accounts for an additional 54% of impacts associated with the product's final intake, whereas for meat or dairy-based products this rate is lower, at 27% and 20%, respectively (Walker, 2018).
In conclusion, the best option is to try to live package free as much as possible when this does not lead to food waste. If one wants to prevent food waste, the best option is the PET material, followed by the can and thereafter the glass. However, only when glass is fully recycled, for example with beer-bottles, then this is a better option than both can and plastic (Milieucentraal, n.d.-c) Although living package free would be recommended, taking all factors into account, the packaging itself does not have a considerably high impact. For non-fresh, long-lasting products, it is recommended to buy larger packages to save material. Larger package units contain relatively less material (Plumers et al., 2011).

Conclusion
From all the different factors that are described above, several conclusions can be made. Firstly, it became apparent that fruits and vegetables cultivated in open ground are generally lower in CO2-eq emissions than fruits and vegetables originated from glass horticulture. Secondly, if fruits and vegetables are seasonal, and thus produced on open ground, the CO2-eq emissions are lower. It is suggested that food products that are harvested in season in another country are a more sustainable option, compared to off-season food products harvested locally. This is in line with the recommendation of R. Helmes (personal communication, June 4, 2020), who recommended to use seasonality calendars to eat with the season. Thirdly, refrigeration plays a big role in the CO-eq emissions in the process of storage. Nevertheless, refrigerated storage is important to preserve the quality of fruits and vegetables. Fourthly, on average transportation contributes less than 10% of the total GHG emissions from food. However, for fruits and vegetables, transportation plays a relatively big role, because of the low average CO2-eq emissions on fruits and vegetables. The large difference in CO2-eq emission between the different transport methods (p.e boat vs plane) makes it important to consider boat transport wherever possible. Lastly, different materials can be used to package food products. The best option is PET material that is completely recycled (*statiegeld*), followed by glass that is completely recycled (like beer bottles). When no full-recycling takes place the weight of the product is important in defining the sustainability of the packaging material. Therefore counts the lighter the better; often then the plastic option is better than can and glass.

2.5 What is the average CO2-eq emission of several commonly consumed fruits and vegetables?

To answer this question we evaluated the methods used by the RIVM. The RIVM published a data set in 2019 that summarized the different CO2-eq scores for different products. Furthermore, to answer this question we spoke with the sector of RIVM that is involved in the sustainability analyses of commonly consumed products in the Netherlands.

Table RIVM
The Dutch RIVM performed a study on the environmental impact of commonly consumed products in the Netherlands (De Valk, Hollander, & Zijp, 2016). RIVM is involved in the sustainability analyses of commonly consumed products in the Netherlands. This data is visualized in a table published on the RIVM website (statline.rivm.nl, Data milieubelasting voedsel). For this study, a Life Cycle Assessment (LCA) was performed. The LCA had an attributional approach, meaning that, the focus was on describing the environmental flows direct to and from a product or process (Dewulf, 2015), and a hierarchical perspective was applied. The LCA was performed following the ISO 14040 and 14044 guidelines. A time horizon of 100 years was used and GHG emissions were recalculated following IPCC-guidelines (2006). Finally, the CO2 equivalent for climate change was calculated. In this study, climate change is described as global warming due to greenhouse gas emissions due to human activities (Vellinga et al., 2019). All life cycle emissions of a product that contribute to climate change were included. Climate change is expressed as the unit kg CO2 equivalent. The life cycle assessment used by the RIVM takes into account the following factors from cradle to plate to calculate the final CO2 equivalent/kg/product (Vellinga et al., 2019):

Primary production e.g: agricultural crops, *cattle, and fish.* This is modulated per country of origin. Per product more countries of origin are defined to match with the market situation in the Netherlands. If no data on the original country was available, the supply of fruit on the market is based on domestic production and import (De Valk, Hollander, & Zijp, 2016).
After-harvesting processing of primary products: for some products the processing of drying and peeling takes place in the country of origin.

Processing of primary products to food products: hereby is assumed that this process is often performed in the Netherlands.
Packaging of products: the type of material is selected based on the current supply in the supermarket. Therefore, products can appear twice in the table. To calculate the contribution of packaging only primary packaging material is taken into account, the (ultimate) material the products is packed in. Furthermore, there is taken into account that the packing material is not recyclable and that it is burnt with energy recovery.
Storage and distribution of products: the products whether or not they are cooled or frozen when kept in the distribution centra ready for transport. Food waste during storage and distribution is taken into account.
Transport: Transport is modulated through the cycle, until sale in the supermarket. This can be by air, water, road or rails.
Sale of products: the products whether or not they are cooled or frozen stored and exposed for sale.
Food losses: Food is wasted in various phases in the chain. These can be avoidable and unavoidable food losses, such as losses in supermarkets and cutting losses during preparation. Products group-specific percentages are used for avoidable food losses and product-specific percentage for cutting losses.
Allocation: If a product has multiple by-products, the environmental impact is distributed among these product flows. In these LCA studies, this distribution, or allocation, was based on the economic value of a product.
Preparation of products at home: This phase contains three components, frozen vs. refrigerated storages at home, cutting whereby losses occur and finally cooking of the products.
Consumption of products at home: Not all the prepared food is actually consumed. This phase contains the impact of food losses to sewer, composting and waste incineration.

Environmental indicators
The environmental life cycle of 1 kg of food on the consumer's plate is expressed by 6 environmental indicators, the so-called "midpoint" effect categories:
Greenhouse gas emissions (kg Co2 equivalent)
Acidification (kg SO2-equivalent)
Fertilization freshwater (kg P equivalent)
Fertilization of saltwater (kg N equivalent)
Land use (m2*year)
Water consumption (m3)
For this chapter, we focus on GHGE (kg Co2 equivalent) only. Later in chapter 3 other environmental indicators are addressed.

Use of the data
Although the publication of the RIVM indicates very precise numbers of CO2-equivalent for the different products, they explained that the numbers are not useful for comparing different specific products. However, the data can be used to make comparisons on a category-level. Nevertheless, it is important to indicate that the communication of the results with specific numbers is not correct and should be avoided. However, we can make a classification of the impact of the different categories in the following way:

Table 13: CO2-eq impact of different food categories

Category vegetables (based classification of voedingscentrum)	Product	Kg Co2-eq available products	Range category:
Leafy vegetables	Spinach, lettuce, endive, turnip greens, purslane, chicory *(witlof)*	Lettuce, average: 0.6864 Spinach frozen: 2.2281 Chicory *witlof*: 0.508	0.507-2.2281
Fruiting vegetables	Zucchini, cucumber, pumpkin, pepper, tomato, eggplant, corn, avocado	Zucchini: 2.6345 Cucumber: 1.877 Corn: 1.7189 Pepper: 3.7103 Tomato: 1.7916	1.7189 – 3.7108
Root and tuber vegetables	Beetroot, carrots, celeriac, radish, rutabaga *(koolraap)*, salsify *(schorseneren)*, parsnip, reddish	Carrots: 0.3998	0.3998**
Brassica vegetables *(koolsoorten)*	Cauliflower, Broccoli, Kale, Chinese kale, Kohlrabi, Red cabbage, Savoy cabbage,	Cauliflower: 1.3624 Broccoli: 1.8357	1.3624-1.8357

	Pointed cabbage, White cabbage, Brussel sprouts, Bok choy	Kale: 1.5995	
Onions	Onion, garlic, leek, spring onion	Onion: 0.4378	0.4378**
Stem crops *(stengelgewassen)*	Celery, fennel, asparagus, artichoke, rhubarb, bamboo	NA	
Sprouts *(kiemgroenten)*	Bean sprouts (taugé), rress *(tuinkers)*	Taugé: 1.985	1.985**
Vegetables that are botanically considered as legumes:	Peas, long beans, pods, string beans, green beans, broad beans,	Peas frozen: 1.1372	1.1372**
Fungi	Mushrooms, fungi	Champignons: 5.2083	5.208**
Legumes	Brown beans, chickpeas, lentils	Brown beans: 1.9701 Chickpeas (cooked): 3.727	1.9701-3.727
Category Fruits	**Product**	**Kg Co2-eq available products**	**Range category:**
Soft fruit	Berries, strawberries, grapes.	Strawberries: 6.4122 Grapes: 1.1004	1.1004-6.4122
Stone fruits	Plums, peaches, apricots, cherries, olives	Apricots: 1.4664 Olives: 2.502 Peach: 0.6918	0.692-2.502
Pit fruit	Apples, pears	Apple: 0.525	0.525
Citrus fruits	Orange, mandarin, lemon, lime	Lemon: 1.1515 Orange: 0.7825 Mandarin: 0.8649	0.7825-1.1515
Exotic fruits	Coconut, banana, kiwi, pineapple, figs, dates, mango, avocado	Pineapple: 1.005 Avocado: 1.4153 Banana: 0.7567 Kiwi: 0.7214 Mango: 1.5061 Figs: 1.08	0.7214 – 1.5061
Dried Fruit	Dried figs, dried dates	Figs (dried): 3.44 Dates (dried): 2.291	2.291-3.44
Melons	Honey melon	Honey melon: 1.167	1.167**
Animal products (as comparison)	**Product**	**Kg Co2-eq available products**	**Range category:**
Red meat	Minced beef, hamburger, veal, lamb, Pork	Minced beef: 30.026 Hamburger: 30.676 Veal: 31.003 Lamb: 86.639 Pork: 12.419	12.419 – 86.639
Poultry	Chicken filet, chicken with skin, turkey,goose, duck	Chicken filet: 10.873 Chicken with skin:13.55	10.873-13.55

*The range is an indicator of the available data published in the RIVM, the individual data per product used is also a range. Therefore the range can even be wider or smaller. This data can be used as an indicator to compare different categories.

** In this category data of only one product is available. Therefore no range can be displayed.

Resulting from this table, it can be concluded that fruits and vegetables when comparing to meat, and especially red meat, contribute to a small extent to CO2-eq emissions. However, food switches can be made between different fruit and vegetable categories, Roel Helmes and the RIVM as well as many literature studies emphasize the importance of switching from an animal-based to a plant-based diet, before making switches within the plant-based category (Rosi, 2017; Pichtel, 2007;Stehfest, 2009). The primary principle should, therefore, be to switch from (red) meat to a plant-based option.

2.6 Which more sustainable options can replace commonly consumed vegetables and fruits with a high average CO2-eq emission?

When thereafter considering switches within the fruit and vegetable category, the results are unambiguous. Therefore, it is important to always incorporate the following considerations:

- Greenhouse horticulture or open ground cultivation,
- Transportation
- Seasonality
- Packaging
- Storage

Rather than focussing on the specific numbers as published in rapports or on webpages (R. Helmes, personal communication, June 4, 2020; Vellinga et al, 2019). These principles are described in the previous section of this report (sub question 1c). Nevertheless, some switches can be recommended based on the results of the table. It can be recommended to switch from dried fruits (e.g dried figs, dried dates) to the fresh version of this product. The main reason therefore is that dried fruits lose water during the drying process, their nutrient content becomes concentrated, with other words, their nutritional density increases. Fresh fruits have a higher volume compared to dried fruit with the same content, therefore the likelihood to overeat on dried fruits is higher when comparing to fresh fruits (Aksoy, 2011). Besides eating meat, overconsumption plays a large role in the way diet contributes to GHG-emission (Vellinga et al., 2019; Groezinger, 2013). In addition leafy vegetables like lettuce, as long as eaten fresh can always be considered as a sustainable and nutritious option. Also, in general, exotic fruits should be consumed less and when possible be replaced by local fruits.

Furthermore, the table from RIVM can be used as an indicator to calculate the impact of different recipes. Once more, this can only be used as a relative comparison, so communication with specific numbers is not advised. As described in the first part of this chapter, the Prepit community in general consumes higher quantities of meat-replacers compared to the average Dutch population, which is positive. On the other hand, they consume fewer legumes and more cheese compared to the Dutch population. These areas provide opportunities for improvement. Therefore the following recipes are examples of how Prepit can use the RIVM table to indicate the sustainability level of meals. It is important to note that, when using data on CO2-eq, one source only should be used. Data from different sources can not be compared because the methods applied can vary enormously.

The numbers resulting from these calculation can be seen as a good indicator for the benefits of switching from meat products to plant-based alternatives. However, the specific numbers can't be communicated to supporters

Couscous with chicken and dried dates
(Allerhande, n.d.-a)

Ingredients (based on 4 persons):

- 2 onions
- 2 zucchinis
- 300 gram couscous
- 5el olive oil
- 350 gram chicken filet
- 100 g dried dates
- 65g pistachio nuts
- ½ cinnamon

LoCo2(co)uscous

4 PERSONEN

Dit heb je nodig:

300 gram couscous
350 gram vegetarische kip stukjes
2 uien
2 courgettes
100 gram zongedroogde tomaten
100 gram verse dadels
65 gram pistache noten

BEREIDINGSTIJD: 30 MIN

To increase the sustainability level of this recipe, the following switches can be made:
Chicken filet can be replaced with a plant-based chicken option or with chickpeas. In addition, the dried dates can be replaced by fresh dates. The calculations of these replacements are shown in table 14.

Table 14 Calculations of replacements recipe *LoCO2(co)uscous*

Original recipe	Plant-based chicken + fresh dates version	Chickpeas + fresh dates version
300 gram **couscous***: 1.3 CO2/kg = 300 gram = 0.39 CO2 2 **onions**: 0.44 CO2/kg = weight 2 onions (140 gram) = 0.062 2 **zucchinis**: 2.6345 CO2/kg = weight 2 zucchini (600 gram): 1.581 350 gram **chicken filet**: 10.837 Co2/kg = 350 gram = 3.793 100 gram **dried dates**: 2.291 Co2/kg = 100 gram = 0.229 65 gram **pistachio nuts**: 3.99 CO2/kg = 65 gram = 0.259	350 gram **plant based chicken****: 4.44 Co2/kg = 350 gram = 1.55 100 gram **fresh dates**: 1.567*** Co2/kg = 100 gram = 0.1567	350 gram **chickpeas**: 3.728 Co2/kg = 350 gram = 1.305 100 gram **fresh dates**: 1.567** Co2/kg = 100 gram = 0.1567
6.317 CO2/per 4 persons	3.999 CO2/per 4 persons	3.754 CO2/per 4 persons

*Couscous has the same sustainability aspects as wheat and other grain products (Voedingscentrum, n.d.-f)
**The average CO2-eq for all the vegetarian option in the table is used
***Number based on % difference between dried and fresh figs

Spaghetti Bolognese with Parmesan cheese
(Based on Allerhande, n.d.-b)

Ingredients (based on 4 persons):

- 300 gram spaghetti
- 400 gram minced meat
- 2 red peppers
- 2 zucchinis
- 1 aubergine
- 1 onion
- 400 gram tomato sauce
- 75 gram parmesan cheese

Pasta No-Carbon-O-Nese

4 PERSONEN

Dit heb je nodig:

400 gram spaghetti
400 gram linzen
2 rode paprika
2 courgettes
1 ui
400 gram tomatensaus
250 gram tomaten
75 gram vegan Parmezaanse kaas

BEREIDINGSTIJD: 30 MIN

To increase the sustainability level of this recipe, the following switches can be made:
Minced meat can be replaced with lentils. In addition, the parmesan cheese can be replaced by cashew nuts and nutritional yeast. The calculations of these replacements are shown in table 15.

Table 15 Calculations of replacements recipe *Pasta No-Carbon-O-Nese*

Original recipe	Lentils + vegan parmesan alternative (nutritional yeast + cashew nuts)
300 gram **spaghetti**: 1.5238 CO2/kg = 300 gram = 0.457 CO2 1 **onion**: 0,44 CO2/kg = weight 2 onions (70 gram) = 0.031 2 **zucchinis**: 2.6345 CO2/kg = weight 2 zucchini (600 gram): 1.581 350 gram **minced meat**=30.026 Co2/kg = 350 gram = 10.509 2 **red peppers** = 3.7103 CO2/kg = weight 2 red paper (280 gram) = 1.036 400 gram **tomato sauce** = 1.167 Co2/kg = 400 gram = 0.467 75 gram **parmesan cheese*** = 13.098 Co2/kg = 75 gram = 0.981	350 gram **lentils****: 2.55Co2/kg = 350 gram = 0.893 75 gram **cashew nuts**: 4.255Co2/kg = 75 gram = 0.320
15.062 CO2/per 4 persons	4.785 CO2/per 4 persons

*The older and harder the cheese, the more milk necessary for 1 kilo of the end product (MilieuCentraal, n.b.-a). For the calculation of parmesan cheese the data of a similar old and hard cheese is used
**For the calculation of lentils an average of legumes available is used.

3. WHAT IS NEEDED IN ORDER TO ACHIEVE BEHAVIOUR CHANGE TOWARDS A MORE SUSTAINABLE DIET AMONG DUTCH CONSUMERS?

For sub question 2, an overview of theories and practices on (sustainable) behaviour change is provided. Besides, barriers of consumers were looked into. Consequently, an analysis of ways to achieve behaviour change towards a more sustainable diet among Dutch consumers is presented.

3.1 What theories and practices concerning behaviour change are applicable for changing to a more sustainable diet?

In order to answer this sub question, the Theory of Planned Behaviour is explained and elaborated on. This theory can be used to explain sustainable food purchasing behaviour. Furthermore, several practices are identified. Here, possible practices on how to change one's diet into a sustainable one are described. Each of these practices are shortly applied to Prepit.

3.1.1 Theory of Planned Behaviour

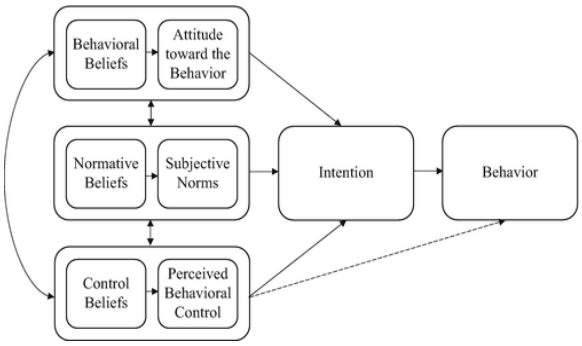


Figure 5: Theory of planned behaviour (Kan & Fabrigar, 2017).

The Theory of Planned Behaviour is a theory developed to 'predict and explain human behaviour in specific contexts' (Ajzen, 1991, p.181). In Figure 5 (Kan & Fabrigar, 2017), different concepts that impact behaviour are displayed. Intention can directly impact behaviour. Besides, it includes the motivational factors of individuals that influence the performed behaviour, and it involves the exertion of effort. The stronger one's intention towards a certain behaviour, the higher the chance that the behaviour will take place (Ajzen, 1991). A concept that can either directly predict behaviour or can act as a determinant of intention, is the Perceived Behavioural Control (PBC). This can be described as an individual's perception of their own control on a certain behaviour, determined by the availability of resources and opportunities. Another factor that can impact intention is someone's attitude towards the behaviour. Attitude can be explained as the (un)favourable evaluation/judgment of a person towards a certain behaviour. Another predictor is the subjective norm, which is the social pressure that is experienced to behave in a certain way. Lastly, beliefs can indirectly determine one's intentions and actions. Beliefs can be divided into behavioural beliefs (which can impact the attitude), normative beliefs (that can play a role in the determination of subjective norms), and control beliefs (which influence the perception of behavioural control). Behavioural beliefs are beliefs that evoke a positive or negative attitude about the behaviour. These beliefs are produced by considering positive and negative outcomes. An example of this could be the question 'What are possible outcomes/benefits of making a certain decision?' (Health Communication Capacity Collaborative, n.d.). Normative beliefs are associated with the subjective norm or the perceived social pressure. Questions linked to normative beliefs are for example: 'How do people expect me to act?', 'What do they expect me to do?', or 'Will people support me or put me in the pillory?'. Lastly, control beliefs can impact behaviour performance. So, for instance, 'Do I have the necessary knowledge/tools/confidence to behave a certain way?' (Health Communication Capacity Collaborative, n.d.).

Results from a study by Robinson and Smith (2002) suggest that consumers generally have supportive beliefs and attitudes towards the consumption of sustainable food products. Besides, more supportive beliefs, attitudes, intentions, and past sustainable purchasing behaviours were prevalent among those who reported themselves to be environmentally concerned and conscious, compared to those who did not report to be like this. Nevertheless, in general, consumers were lacking confidence in their ability to buy sustainable food products and they did not tend to show supportive past purchasing behaviours (Robinson & Smith, 2002).
It appeared that the intention to buy sustainable food was mostly predicted by psychosocial variables, such as beliefs, attitudes, and self-identity, and past purchasing behaviour (Robinson & Smith, 2002). From a study conducted by Vermeir & Verbeke (2008) it appeared that attitude, perceived consumer effectiveness (the perceived contribution to the

solution of a problem by one's personal actions), perceived availability (perceived ability of consumers to obtain/consume a certain food product) and social norms positively impact the intention to consume sustainable food products. Besides, confidence is suggested to contribute to the intention of sustainable purchasing behaviour (Vermeir & Verbeek, 2008). Of all predictors of intention, attitude is considered to play the biggest role, which is why a positive attitude is very important when trying to promote sustainable consumption behaviour (Vermeir & Verbeek, 2008). It can, therefore, be recommended to reach consumers by engaging with their beliefs and attitudes about sustainable food. Also, it can be helpful to include possible values and benefits of sustainable food, when trying to raise awareness among consumers that are not yet informed (Robinson & Smith, 2002).

"Of all predictors of intention, attitude is considered to play the biggest role, which is why a positive attitude is very important when trying to promote sustainable consumption behaviour"

However, a positive attitude does not always lead to the desired intention of sustainable consumption behaviour. The step from attitude to intention is mainly impacted by social influences and PBC. PBC involves perceived availability and perceived consumer effectiveness, which both affect intention. In this case, people who feel social pressure towards sustainability, are more likely to have the intention to purchase sustainable food products. However, from the study by Vermeir & Verbeek (2008) it appeared that high social norms were not so much experienced by respondents. Besides, consumers that consider it to be easy to obtain sustainable food products are more likely to buy these products, and the same accounts for consumers that feel like their personal actions can have a positive impact.

3.1.2 Practices

Hyland, Henchion, McCarthy, & McCarthy (2017) have identified several ways to promote sustainable diets, and more specific diets that have reduced greenhouse gas emissions (GHGE).

Taxes

The first strategy that is mentioned is the implementation of the Pigovian tax on meat, which signifies higher meat prices (Hyland, Henchion, McCarthy & McCarthy, 2017). This tax includes the social costs of meat, based on its environmental impact. According to the authors, such taxes could then also be applied to other unsustainable food products, in order to reduce theally be effective in reducing the purchasing behaviour. Such e amounts of unsustainable food products purchased and consumed. However, this is not something Prepit will be able to perform (by itself).

Food labels

Another way to reduce the CO2-eq output of one's diet, is food labelling on the ecological footprint of food products (Hyland, Henchion, McCarthy, & McCarthy, 2017). By this, different food products are labelled by their ecological footprint, and these labels then can be widely used and accepted. This kind of food labelling has been acknowledged as meaningful and as effective in impacting consumer purchasing behaviour. However, at the same time, consumers generally do not have knowledge of the underlying explanation on footprints of the food products, when only the final score/outcome on sustainability is labelled (Hyland, Henchion, McCarthy, & McCarthy, 2017). Therefore, it might be important to provide an explanation of how the ecological footprint is estimated, and how the score/outcome of sustainability is decided upon. For Prepit, it could be recommended to create some sort of food label that expresses the ecological footprint for a certain food product/dish, that enables consumers to quickly get a view of the ecological footprint of that certain food product/dish. This label could be used on the Instagram or website of Prepit when addressing a certain food product or dish. It would then be helpful to include a short explanation of this score/outcome to inform consumers about the underlying estimations of the footprint.

Health

A study conducted by Hoek, Pearson, James, Lawrence, & Friel (2017) even suggests that health is the main driver to consume healthy and sustainable food products. They state that health can play a bigger role, since health directly benefits the consumer personally. When a certain food product is stated beneficial for the environment, this is seen as an additional benefit, rather than an actual reason to buy this product. Consumers are more likely to choose a certain food product when they expect the product to taste good, when they consider the price as attractive, and when the option is convenient and familiar to them. The study recommends creating associations between benefits for one's health and for the environment in marketing and communication of a certain food product. For example, this can be achieved by using words such as 'naturalness', which both applies to health and sustainability (Hoek,

Pearson, James, Lawrence, & Friel, 2017). From this information, it can be suggested that it would be helpful for Prepit to include the aspect of health in their recommendations, while still focussing on the aspect of sustainability. According to Maciarmid (2013), environmental and health aspects and recommendations on food can often be combined. Although it is not applicable for all food categories (e.g. fish is recognised for its health benefits, but is not considered very sustainable, because overfishing is a serious issue worldwide), for example tackling obesity and reducing meat consumption can have benefits for one's health, as well as for the environment (Maciarmid, 2013).

Meat-reduction

Since meat reduction plays an important role in reaching a more sustainable diet, some practices on meat reduction specifically are described below. Meat reduction can be achieved by completely eradicating meat from one's diet, by consuming smaller portion sizes, or by consuming meat less often (Verain, Dagevos, & Antonides, 2015). It is suggested that ethical motives, such as animal welfare, environmental impact, and aspirations, are often the main reason to completely eradicate meat from one's diet. For a slightly reduced consumption of meat, health concerns are considered the main reason for consumers (Verain, Dagevos, & Antonides, 2015). From this, it can be concluded that a focus on either or both ethical motives and health concerns can support a reduced consumption of meat. Prepit could include animal welfare, environmental impact, and health aspects in their messages to achieve an overall reduction in the amount of meat consumed.

Reduction versus replacement

Furthermore, some people may prefer reducing their intake of food products with a high environmental impact, while others may be willing to purchase sustainable food products. According to the study by Verain, Dagevos & Antonides (2015), people are more likely to reduce their meat consumption (eliminating meat for one day a week or eating reduced portion sizes), rather than buying sustainable alternatives. Compared to meat, reduction of one's dairy consumption was significantly less desired among consumers, and also the desire to buy more sustainable dairy alternatives was low (Verain, Dagevos, & Antonides, 2015). Here, it can be suggested for Prepit to focus on curtailment of meat and other unsustainable products, rather than focussing on the promotion of sustainable alternatives. However, from the survey it appeared that the Prepit community does eat relatively many meat substitutes. This implies that for Prepit it would be good to focus on both reduction of meat intake, as well as meat substitutes.

Food waste and food loss

As mentioned before, food waste and food loss take place in all stages of the food supply chain. Both food waste and loss should be prevented in order to achieve sustainability. Therefore, Prepit could include these two concepts into recommendations on a sustainable diet. Up to now, Prepit has been looking at the CO2-eq up to the retail level and has not taken into account the food waste at home. However, Prepit@Home already provides the exact amount of ingredients needed for the dish, to prevent food waste. Another option would be to provide Prepit@Home users with tips on what to do with the leftovers.

Nudging

Another strategy to encourage switching to a more sustainable diet, is by making use of nudging. Nudging implies adapting the complex food environment in order to steer consumers unconsciously to certain choices (Vandenbroele, Vermeir, Geuens, Slabbinck & Van Kerckhove, 2019). This means that consumers do not have restricted choices, but rather that the choice architecture is adapted wherein the consumers operate. However, this is not something Prepit can fulfill on its own.

3.2 What are barriers for adapting a sustainable diet, experienced by consumers?

Below, several barriers are explained that can be experienced by consumers when adapting a sustainable diet.Often it is assumed that people act rationally or according to their personal preferences, and that therefore providing knowledge will lead to behaviour change (Lehner, Mont & Heiskanen, 2015). However, studies have shown that resolving the knowledge gap and having the intention to examine a certain behaviour does not by definition lead to actual adaptations in behaviour (Abrahamse, Steg, Vlek & Rothengatter, 2005; Steg & Vlek, 2009). In the case of Prepit, some consumers do know about the advantages of adapting a more sustainable diet, and may even have a personal preference towards a sustainable diet already. However, somehow, not all are able to act accordingly. This is called the intention-behaviour gap (Sniehotta, Scholz & Schwarzer, 2005). Thus, when it comes to actual consumption of food products that are environmentally friendly, an inconsistency between consumers' attitudes towards sustainable food products and their actual behaviour is observed.

Wealth and Status

The first barrier for adapting a sustainable diets that shifting behaviour challenges individual goals of wealth and status (Cromptom & Kasser, 2010). Wealth and status are often linked to someone's personal identity, and therefore people will look for a manner to negate the information. This implies that behaviours to not eat sustainably are 'embedded' structurally and ideologically, which makes them highly challenging to change (Goel and Sivam, 2014). One example of a food product whereby wealth and status are often playing a role is meat, whereby on average relatively high CO2 emissions are released. Meat is in many societies seen as a dominant and traditional part of an eating pattern, and has symbolic and cultural meanings (Leroy & Praet, 2015). Especially in countries that are going through economic transition, meat is associated with a high status and appraised as a symbol of capital (Popkin, 2006; Smil, 2002). Furthermore, certain food products such as meat are associated with masculinity. Particular framings of masculinity underline that 'real men' eat meat, which negatively influence the transition to a more sustainable diet (Schösler, de Boer, Boersema & Aiking, 2015).

Lack or overload of information

The second barrier is a lack or overload of information (Terlau & Hirsch, 2015). Sustainable focused consumers have in general a unique demand for product information. Many consumers feel insufficiently enlightened about the social and environmental impact of food products which often lead to 'cognitive dissonance'. Cognitive dissonance may result in mental stress when consumers have to make decisions in equally attractive food products because of emotions, values, attitudes and intentions involved (Hughner et al., 2007; Honkanen et al., 2006). An example of this is when consumers want to buy the most sustainable cheese product, but because of an experienced lack of information they do not know which one to buy. Consequently, cognitive dissonance is observed. At the same time, there are consumers that experience an overload of information regarding sustainable consumption because of, among other things, the high amount of various labels and certifications available. There is an increasing number of voluntary eco-labels on food products in the marketplace, which leads to consumer confusion between self-declared labels and third-party certified labels (OECD, 2008). This overload of, sometimes contradictory, information about sustainable diets can challenge someone's capacity to deal with this information. Consequently, consumers do not understand how they can make sustainable food choices (Moisander, 2007). Thus, a lack of structured, unambiguous knowledge about buying sustainable food products leads to the fact that consumers do not know what food decisions to make.

Habits

The third barrier is that food purchases in general take place by well-established consumption routines (habits). Habits can be characterized by repetition, automaticity, and context (Verplanken, 2010). Problematic levels of unsustainability are created because of the effect of repetitive behaviours performed by many people. For example, making a trip by car every now and then is quite harmless, but when large populations habitually use the car instead of other alternatives there is an actual impact. The second characteristic of habits is automaticity, which signifies a lack of conscious intentions and awareness, limited feelings of control, and mental efficiency (Verplanken & Orbell, 2003). People make food decisions very quickly, without completely weighing the consequences (Verplanken & Orbell, 2003). Automaticity can even lead to a so called 'tunnel vision', implying that it is difficult to attend to new information, even if these are more optimal options (Klöckner and Verplanken, 2013). The third characteristic of habits is about the context in which the habit takes place. The context can influence and automatically trigger a certain habit. When this happens, the control has slightly shifted from the individual to the context or environment (Orbell & Verplanken, 2010).

Perception of individual impact

The fourth barrier is the perception of sustainable food products playing only a small role in a global context (Macdiarmid, Douglas & Campbell, 2016). Many consumers believe that changing their own diet into a more sustainable one will only make a minimum difference in fighting climate change, because others in their surroundings do not change diets too. Besides, some consumers argue that they have little control in reducing environmental impact because their choices about their food products are controlled by large retailers and businesses. There is a certain sense of distrust in big supermarket chains because some supermarkets are only selling imported food products while the same products are also produced seasonally and locally. Furthermore, some consumers assume that other human activities such as pollution from industries, transportation, and land clearance for other purposes than food, are more environmentally damaging than certain food products (Macdiarmid, Douglas & Campbell, 2016). All these perceptions can be captured as the perceived consumer effectiveness (PCE), also shortly mentioned earlier,

signifying the extent to which consumers believe that their
individual efforts can contribute to the resolution of a problem, in this case climate change. A high PCE is crucial for consumers to convert their positive attitudes into actually buying more sustainable food products (Ellen et al., 1991; Berger & Corbin, 1992; Roberts, 1996; Lee & Holden, 1999).

Perceived price
The fifth barrier in adapting a sustainable diet is the perceived high price of purchasing sustainable food products. Prices play a pivotal role in consumers' buying behaviour, depending on various aspects such as price consciousness, social-economic status, and willingness to pay (WTP) (Aertsens, Verbeke, Mondelaers & Huylenbroeck, 2009). The price of sustainable food products is sometimes perceived as a barrier, especially for consumers with a lower income. Assumable is that the WTP is lower for food products with low CO2 emissions compared to organic food products because food products with low CO2 emissions do not give any personal benefits such as health (Röös, 2013). Besides, consumers might experience a lack of knowledge about the prices of sustainable food products and therefore overestimate the costs of switching to a more sustainable diet. This implies that a large group of consumers is excluded from a sustainable diet (Aschemann-Witzel & Zielke, 2017).

In conclusion, there are five main barriers experienced by consumers for adapting a sustainable diet. These barriers are summarized in a visual overview down below (figure 6).

Figure 6: Barriers for adapting a sustainable diet.

3.3 What are effective communication strategies in order to achieve behaviour change towards a more sustainable diet?

Message framing
As seen before, a main challenge of communicating about sustainability is to transmit information in a manner that achieves an actual change in behaviour (Juárez-Bourke, 2018). The research by Juárez-Bourke (2018) shows that there is a need to increase the role of emotions, norms, values and trust to generate the change in behaviour. This will be further elaborated in the paragraphs below.

A study conducted in New-Zealand indicated that providing information on the climate impact of meat consumption was associated with significantly increased levels of concern regarding the climate impact of meat consumption (Graham & Abrahamse, 2017). Furthermore, providing this information significantly lowered the intention of people to consume meat. Providing information as a communication strategy for changing people's behaviour is based on the knowledge-deficit model. This model hypothesizes that people are more probable to change their behaviour when they know how and why they should alter their behaviour (Schultz, 2002). Prepit provides information mostly on how people can change their behaviour, which according to the knowledge-deficit model increases the probability of behavioural change. If people know how to alter behaviour, this could lead to a decrease in the intention-behaviour gap. However, as discussed in previous paragraphs, providing information does not automatically lead to a change in behaviour (Graham & Abrahamse, 2017).

The study by Graham & Abrahamse (2017) also showed that the framing of the message had an effect on the attitude towards meat consumption. Further, it is believed that the most effective framing differs per person. A distinction can be made between people with high self-enhancement values and high self-transcendence values. Those with high self-transcendence values are likely to have concerns for the welfare of others or the environment. Those with high self-enhancement values are more likely to have more self-centered goals. It is hypothesized that people with an interest in Prepit mostly have high self-transcendence values, since they show an interest in the environment. For people with high self-transcendence values, a message framed with a focus on the collective effect had a smaller effect on the meat consumption intention, since those people already thought these problems were important. Therefore, for the target group of Prepit (environmentally conscious consumers), the

message would be most appealing if it has a focus on the effects of sustainable consumption on an individual level. An example of a message could be "By making this food switch, you can reduce your individual carbon footprint".

Another study investigated what images and icons are most effective for climate change communication. It has been shown that, even though it catches people's attention, fear is in general not effective to increase legitimate personal engagement (O'Neill and Nicholson-Cole, 2009). A fear-inducing or dramatic image of climate change can give the consumer feelings of distance and disempowerment, which is counterproductive for increasing the public engagement. An image or text that matches the everyday emotions and interests of people tend to be the most effective.

Target group characteristics

To make the communication as effective as possible, it may be useful for Prepit to outline its target group more precisely. The effectiveness of message framing can be increased when it is tailored to a specific target population (Cheng, Woon & Lynes, 2011). The strategies for message framing specific to affect environmentally friendly behaviour are investigated. The characteristics of the target population influence to a large extent which messages can be used for effective framing. Three main target group characteristics can be identified, which are described in the following paragraphs.

The first characteristic is the level of engagement in environmental behaviours, since consumer's level of engagement in environmentally sustainable behaviour influences the effectiveness of certain framing of a message. It is expected that people with high self-transcendence values have higher levels of engagement in environmental behaviours. There are different levels of engagement in pro-environmental behaviour (PEB). In addition, there are different message framing methods, focusing on positive outcomes from engaging in a behaviour (gain-framing) or on negative outcomes, which may be the effect of not engaging in the beneficial behaviour (loss-framing) (Bosone & Martinez, 2017). According to Cheng & Woon (2010), looking at loss-frame adds leads to lower intentions to drive in non-drivers and adolescents with low environmental behaviour engagement. If Prepit wants to reach people with a low environmental behaviour engagement, it is important to realize that for them other message framings will be more effective than for already highly engaged people. It is expected that a loss frame will be more effective to encourage people with low environmental behaviour engagement to adopt sustainable eating habits. A loss frame would be: "If you don't eat less meat, you will contribute to the rising of the sea levels". A downside of using loss-frames would be that people avoid issues which evoke unpleasant feelings, since emotions play an important role in decision-making and motivation (Lang & Bradley, 2010). The avoidance of negative emotions has a direct effect on PEB, due to reduced tendency to seriously think about environmental issues. This is due to the fact that contemplating climate issues evoke unpleasant feelings, which make people stop thinking about it. This decreases the motivation to develop mitigating actions in the form of PEB. It is important for Prepit to consider the tendency to change of its community, since this has implications for effective message framing. In Prepit perspective, a gain frame could be "If you eat less meat, you will contribute to the maintenance of the sea levels". For Prepit, this would mean that it is not possible to share a message both effective for high and low environmentally engaged people. It is proposed that Prepit keeps focusing on reaching highly engaged people and that gain-frames will be used to effectively communicate with them.

"For Prepit, this would mean that it is not possible to share a message both effective for high and low environmentally engaged people."

Further, the factor risk should be taken into account for effective framing (Cheng et al., 2011). If the choice is framed in the terms of related advantages, people tend to be more risk-averse. For preventative behaviour, gain frames seem to be more effective. Also, the research by Morton et al. (2010) suggested that when communicating climate change, an emphasis on the possibility that certain outcomes can be avoided was associated with a more effective reaction. Climate change is associated with great uncertainty, and thus with risk, and without the emphasis on the possibility to prevent some of the consequences people have a decreased intention to do something about climate change. If Prepit continues to offer easy and affordable recipes, people can experience high levels of self-efficacy and have the feeling they can contribute.

3.4 What advice is proposed when aiming to achieve behaviour change towards a more sustainable diet?

A communication advice for Prepit is proposed based on the described practices, barriers, and information about effective communication. Firstly, it

is recommended to induce a positive attitude about sustainable food products, by mentioning its values and benefits. Hereby, it turned out that it is important to focus on an individual level because we expect the target group to have mostly high self-transcendence values. The barrier of a low PCE among consumers can be avoided in this way, since consumers then get the idea that they, individually, can make a difference. When consumers are approached at an individual level, their attitude might be positively impacted and it will lead to consumers actually buying more sustainable food products. For example, a message could be "By making this food switch, you can reduce your individual carbon footprint by…". Prepit could post an image on Instagram or the website of one's individual contribution to the environment (for example water loss) by comparing an unsustainable food product with a sustainable one.

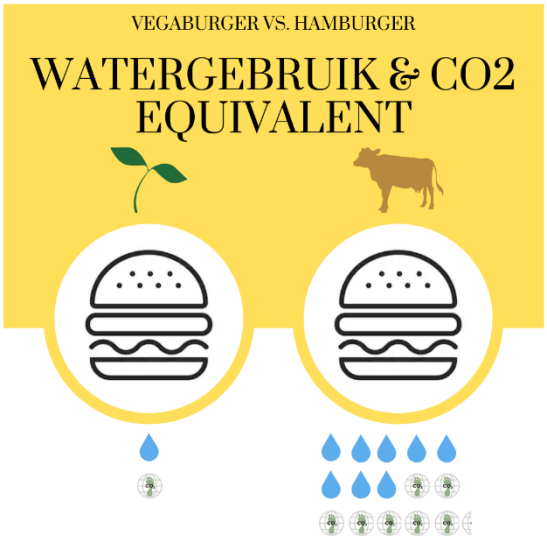


Figure 7: Water use and CO2 equivalent of meat vs meat substitute (Nantier,2020).

In the figure 7 above , an example of an Instagram post is created for Prepit on water use and CO2 equivalent. On the left, a meat substitute is displayed, and on the right the meat burger is presented. The water use of a meat burger is eight times higher compared to an average meat substitute. The CO2 equivalent of a meat burger is generally 22 kg CO2 eq/kg product, whereas the equivalent of a meat substitute is estimated to be around three kg CO2 eq/kg product.

Secondly, it is stated that consumers are more likely to change their consumption behaviour when they know how to do it. When these changes are considered to be easy, there is a higher chance for people to consume differently. The barrier of food choices mainly determined by people's habits can be overcome by making the food switches seem as easy as possible. This can be done by offering alternative, more sustainable, ingredients for a recipe people are familiar with. So, for instance, when sharing a recipe on the Prepit Instagram or website, it should be a familiar dish, but with easy to implement sustainable adaptations. For example, a non-vegetarian dish can be made vegetarian by simply replacing the meat for a meat substitute. Prepit already succeeds in this by offering Prepit@Home meals, where familiar dishes are converted into a more sustainable dish.

Besides, there is a general lack of knowledge on prices of sustainable food products. People often have the idea that switching to a sustainable diet would be more expensive. Therefore, it could be useful for Prepit to emphasize that a sustainable diet does not have to be expensive. This could be done by, for instance, posting two food products and its price; one unsustainable food product and one sustainable alternative. For example, the price of beef is generally higher than a beef substitute. This could encourage people to buy the (cheaper) sustainable alternative instead.

Figure 8: Comparison in prices of meat with sustainable alternatives (Lidl,n.d.).

In figure 8, an example of such an Instagram post is shown. Here two prices are displayed; the price of two vegetarian juicy steaks (€1,99) and the price of two steaks. By comparing these two prices, consumers will realize that eating more sustainably does not have to be expensive, and that it is sometimes even cheaper than to eat meat.

Another advice that can be put forward, is that Prepit could develop a standard label that expresses the ecological footprint for a certain food product/dish.

This label could give consumers the opportunity to quickly get an idea of the ecological footprint. This way, information is structured and unambiguous. This can avoid that consumers do not know what food choices to make in order to contribute to sustainability. It is important to include a short explanation of the score/outcome of this label, to make sure consumers are well informed about the underlying estimations. As mentioned before, icons are most effective to communicate about climate change and/or sustainability. These should, however, not be fear-inducing or dramatic, so that it doesn't give the consumers a feeling of distance and disempowerment. An option for such a label could be a traffic light which displays a red, orange, or green light. The red light would indicate an unsustainable food product/dish, and a green light would be a very sustainable option (Roberto et al., 2012). Since Prepit does not develop its own food products, the label will only be used for the recognition of the ecological footprint of a food product/dish for the Instagram and website.

For figure 9, an example of a label was created which Prepit could use for their Instagram/website. It is another version of a traffic light, where green represents a favourable CO2 equivalent, and red represents an unfavourable CO2 equivalent. The ranges of the different colours are not yet decided upon. An example was made for the meat product, where the amount of kg CO2 equivalent was considered unfavourable, and therefore indicated with the red colour of the traffic light. The meat substitute has a relatively low ecological footprint, which is represented by the green colour.

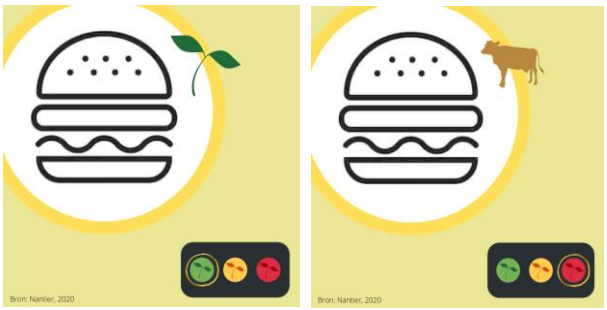


Figure 9: Sustainability label traffic light

Furthermore, it was stated that health is the main reason for people to consume healthy and sustainable food. Health is something that directly personally benefits the consumer, whereas the environment is often seen as an additional benefit that is not directly personally linked to the consumer. Therefore, Prepit could include the health aspect in their recommendations on sustainable food products, since sustainable food products are sometimes considered to be healthy, too. For example, when making a recommendation for a sustainable food product, it can be useful to highlight the health benefits as well. An example of this could be, when stating that meat is generally bad for the environment, Prepit could mention that red/processed meat also gives a higher chance on cardiovascular disease and colorectal cancer (Godfray et al., 2018).

Another recommendation for Prepit is to be aware of the symbolic and cultural meanings of some food products. An example of such a food product is meat, whereby it is often framed that 'real men' eat meat. This can negatively affect the transition to a more sustainable diet. One way to address this, is by posting gender neutral pictures or icons whereby sustainability is promoted. Another way could be to make the Instagram page and website slightly more attractive and accessible for every gender.

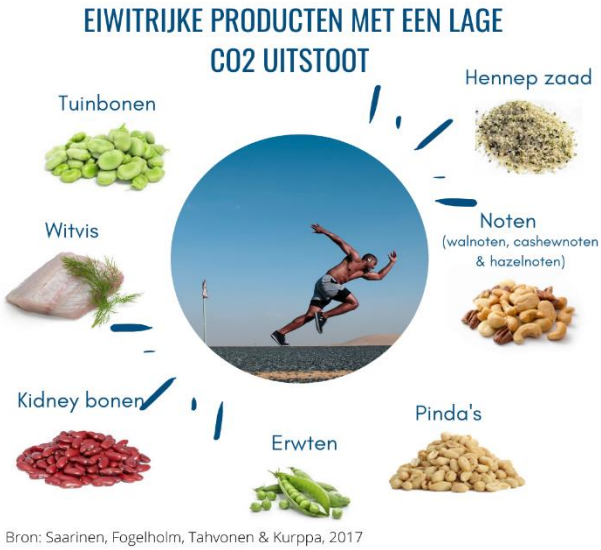


Figure 10: The most environmental-friendly food sources of protein (Saarinen, Fogelhorm, Tahvonen & Kurppa, 2017

In figure 10, the most environmental-friendly food sources of protein are shown. By highlighting that doing sports and consuming protein is also possible when eating sustainably, more people will feel attracted to a sustainable diet. In this way, eating sustainable is more accessible for every gender.
Further, Prepit should be aware of the characteristics of its target group and adjust its messages to fit this target group. Lastly, Prepit could take into account the importance of food waste and food loss. These aspects play an important role in a more sustainable diet. Recommendations could emphasise the importance of both food waste and loss.

4. TO WHAT EXTENT DOES CO2-EQ EMISSION REDUCTION OF FOOD CONTRIBUTE TO COMBATING CLIMATE CHANGE?

The following chapter will focus on the phenomenon of CO2-reductionism. It is found that this is important to include in this report since it offers a renewed perspective on the problem of climate change and potential pitfalls of the Prepit platform. The chapter will firstly address the concept of CO2-reductionism, which explains what dominates the current debate on climate change and why this happens. This will be followed with a critical analysis of what CO2-reductionism entails and its relation to 'solving' the problem of climate change. Secondly, a couple of different alternative perspectives will be provided with an explanation and argumentation why these perspectives better cover the complexity of the climate problem. Finally, this information will be translated into a practical tool in the form of a food passport, so as to integrate this information with the Prepit platform. A food passport summarises the pros and cons of a specific product, taking into account this broader range of determinants. This can be used to make the consumer aware of the complexity of the problem and the multiple factors involved in the process. Below, each of the sub questions can be found.

4.1 Which factors, besides CO2-eq emissions, are important to take into account for calculating an ingredients environmental impact?

The emission of CO2-eq has a significant impact on earth's warming climate (Montzka, Dlugokencky & Butler, 2011). Once all direct and indirect impacts are summed up (e.g. farming from CH4 and N2O emissions and agriculturally induced deforestation), the emissions of agriculture has been approximated to be 30% of total global emission (Garnet, 2013). However, as discussed in the former question, the output of CO2-eq is only one of the problems with the lack of sustainability in our food systems. In addition to CO2 release, deforestation as a result of large-scale agricultural production is the main cause of the loss of biodiversity. Furthermore, 70-80% of all human water withdrawals (freshwater taken from ground or surface water sources) is also attributable to deforestation and is an important determinant for the pollution of water (Garnett, 2012). Due to deforestation, the movement of water into the atmosphere is disrupted, leading to major shifts in rainfall patterns (Fred Pearce, 2018). This is a huge problem, since the scarcity of water is becoming more common around the world, the rates at which water is extracted for irrigation are greater than the rates at which it is replenished in most places of the world. (Jägerskog & Jonch, 2012; Dangour et al., 2012). In addition, it has been found that using fertilizers, N-fixing legumes and manure are disrupting global Nitrogen- and Phosphorus-cycles. These cycles are needed to continuously cycle elements between different environmental compartments. Examples of these compartments are the water, soil or air (Greenfacts, n.d.). This has a negative impact on the quality of water, aquatic ecosystems and marine fishing (Foley et al., 2011). Studies show that not all food products contribute equally to previous mentioned climate-related issues (Williams, Audsley & Sandars, 2006; Conforti, 2011). A share of these environmental impacts can be attributed to the large-scale agricultural developments during the green revolution. The current agricultural production system we have, originates from the green revolution in the 1950s and the 1960s (Khush, 2001). During these times, there was a demand for industrial development and more extensive food processing. Due to these developments, food became more widely available and affordable to more people, and preparing food became more convenient (Council, 2011). The agricultural revolution resulted in a number of unforeseen negative consequences and created a dependence on fossil-fuel driven energy for transport and the synthesis of pesticides and fertilizers (Dangour et al., 2012).

The environmental problems are not the only problems arising from the current global food system. Other problems concern the increasing level of low nutritional food products resulting in high rates of obesity on the one hand, and persistent undernutrition on the other hand. Besides this, the current food system is dominated by powerful stakeholders leading to unequal distribution of wealth (International Panel of Experts on Sustainable Food Systems, 2015). It is beyond the scope of this report to address and explain these different issues, the alternatives discussed below however, attempt to take these different issues into account and demonstrate how they are all interrelated. In order to change something about global warming and secure future food production, many aspects will have to be

addressed. In what follows, two different approaches will be addressed which both aim to tackle the issues in the food industry at its roots.

Food System approach

The first one concerns the 'food systems approach'. Food systems gather all elements (e.g. people, environment, processes, inputs, infrastructures and institutions) and activities relating to producing, processing, distributing and consuming food. Furthermore, also outputs related to these previously mentioned activities are included. On top of that, also socio-economic and environmental outcomes are part of this (FAO, 2017). This approach highlights the role of the food environment in making sustainable food choices. In addition, it emphasizes the role of three important elements of food systems, which are food supply chains, food environments and consumer behaviour. A food supply chain includes all activities that bring food from its production to its consumption. This process encompasses for example harvesting, storage, processing, distribution, packaging or marketing of food products. A way to increase the sustainability of food products is for example by shortening the supply chain. Short supply chains reduce transportation costs and therefore CO2-eq emission as well. While it is argued that transportation has a relative low contribution to a food product's total CO2-eq emission (Ritchie, 2020), it does not necessarily mean that the whole idea of promoting local food should be abolished. When focussing on CO2-eq emissions only, transportation is relatively unimportant.

When focussing on climate change as a whole however, the origin of food products can play a highly important role. Connecting consumers to the natural production of their food can create increased consciousness and engagement with sustainability and reduce the negative environmental impact of current dietary patterns (IFOAM, 2016). Short supply chains re-connect consumers with the food they eat (European Network for Rural Development, 2012). The ENRD (2012) found that the consumers who are concerned with the environmental and health effects of their dietary patterns are showing increased interest in the origins of their food. The short-supply chain enables direct communication with the producers and consumer and thus provides easier access to information.

Furthermore, short supply chains have a positive effect on biodiversity and help to implement agriculture in regions that surround large population centers (Canfora, 2016). Another important element of a food system is the food environment, encompassing the physical, economic, political and socio-cultural context in which consumers can find themselves. The food environment has a major impact on food choice, food acceptance and diets via for example the promotion of food, advertisements and information. Furthermore, it impacts food quality and safety (FAO, 2017). Lastly, an aspect of the food system influencing sustainability is consumer behaviour, focusing on both consumer choices at either individual or household level. It is about which food is chosen, how it is stored, prepared, eaten and about how the food is distributed within the household (FAO, 2017). The human population has increased the total CO2-eq output by more than 33% by way of deforestation, urbanisation, manufacturing, the emission of cars and fossil fuel burning. Waste management by consumers also influences GHG emissions, for example to trash or recycling disposal. For this reason, consumption is innately connected with sustainability, since consumers make their own choice about what they buy, how much they buy and consume and how a product will be disposed (Trudel, 2018).

'Sustainable Diets'

The second approach concerns the 'Sustainable Diets' as analyzed by Johnston, Fanzo and Cogill (2014). While there are different definitions of sustainable diets, the authors use the definition as defined by the FAO (n.d.-a), and goes as follows: "Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources." The most important categories of analysis of sustainable diets are agriculture, health, sociocultural, environmental and socioeconomic factors. These different categories cover determinants and dimensions which are all interrelated, any changes in processes or factors in one of these determinants to have an effect on other determinants as well. Due to this reason, it affects the level of sustainability of the diet. Since this network of determinants for sustainable diets is quite complex, it is hard for politicians to understand the benefits of sustainable diets. Consequently, it is challenging for policymakers to promote those diets. Even though the sustainable diet concept is not a new concept, it remains a complex concept with many gaps in our understanding of what such a sustainable diet includes. To be able to understand what a sustainable diet means, agricultural, socio-cultural,

environmental and economic categories should be investigated (Johnston, Fanzo & Cogill, 2014). These categories and their corresponding dimensions are depicted in figure 11. Each dimension has a direct link to the pink circle in the middle of the figure representing the sustainable diet. In the following paragraph these different dimensions and their corresponding influence on the sustainability as a whole will be explained.

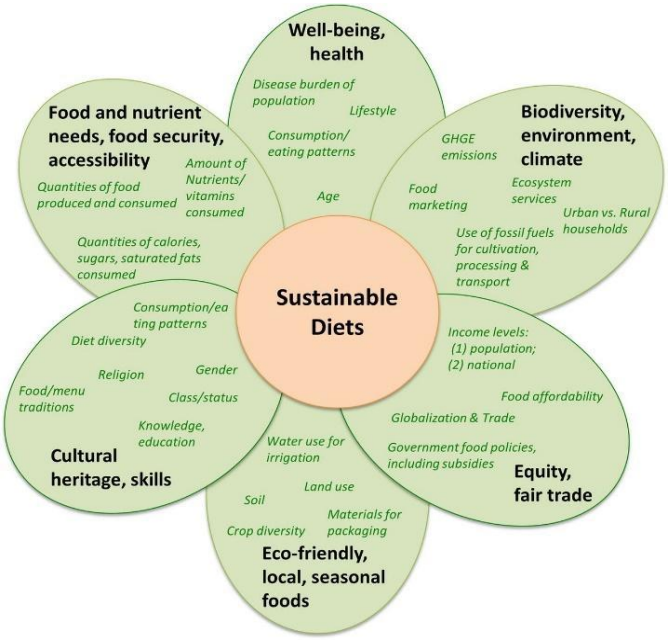


Figure 11: Dimensions of sustainable diet

The first category concerns the economic, which is important since it provides insight into how income is distributed among a population or a nation has a big influence on the affordability of a diet. When people have a higher income, they are able to buy a greater variability of foods and more nutritious foods (Council, 2011). Other aspects of this category are for example globalisation & trade, government food policies and food affordability. Food subsidies for example can have a great influence on the price of (un)sustainable food products and thus the demand for these products (Johnston et al., 2014). This economic dimension of food is categorised under the dimension of 'equity, fair trade'.

The second category outlines the influence of agriculture and concerns information on agricultural methods and its influence on sustainability. As discussed in the first paragraph, the green revolution explains many of the current negative agricultural practices such as the high use of fossil fuels, high CO2-eq emissions, negative influence on ecosystem service. Agricultural methods and practices hold an important share and influence on the overall level of sustainability of a diet (Johnston et al., 2014). This agricultural category can be found in the figure under the dimension 'biodiversity, environment and climate'.

The third dimension is related the health dimension of a diet and concerns information on the nutritional value and availability of food. A healthy diet with sufficient nutrients and calories increases a person's productivity and can therefore also influence agricultural productivity and a series of ecosystem services. In turn, the rise of low-nutrient and energy-rich food products increased the triple burden of nutrient deficiency, obesity and undernutrition (Johnston et al., 2014). The health category can be found under the dimensions of 'well-being, health' and 'food and nutrient needs, food security, accessibility'.

The fourth dimension concerns the socio-cultural dimension of sustainable diets and highlights the importance of cultural appropriate food products, knowledge on food preparation and lifestyles and eating habits. It is argued that for example overeating can be associated with stress and watching television. It is important to take these underlying socio-cultural facts into account when promoting and analysing sustainable diets (Johnston et al., 2014). The socio-cultural category covers the dimension of 'cultural heritage, skills' in the figure.

The fifth and final dimension is related to the environment and concerns the relation between environment and dietary choices and human interactions. The environment can directly influence agricultural production and thus dietary choices, in turn dietary choices may affect the surrounded ecosystems (Johnston et al., 2014). This category covers the dimensions of 'eco-friendly, local, seasonal foods' and 'biodiversity, environmental, climate'.

The relation between food and environment is complex. Though efforts are being made to propose alternative approaches, there is not enough common ground and agreement among relevant stakeholders so far to adopt one of these approaches. Both the 'sustainable diets' and 'food-system approach' can provide insights into the complexity of the problem and the underlying relations between the different determinants of 'sustainability'.

4.2 What are the consequences of reducing the problem on the environmental impact of food to only its CO2-eq emissions?

The concept of sustainability in general and the concept of food sustainability particularly involve multiple aspects and interpretations. It entails multidisciplinary aspects, dealing with many key issues from economy, society and ecology (Aiking & de Boer, 2004). However, many of the proposed 'solutions' thus far have been especially focused on reducing the level of carbon emission. As a result, it is placed

out of context and leaves out the environmental, social and even climate context (Moolna, 2012). Politicians and corporations find this beneficial, since it simplifies a complex problem into a more understandable concept and makes climate tradable from a business perspective (Moolna, 2012). In this way, politicians and corporations can redefine the problem to their liking and what is profitable for them. Reducing the complex problem to a single issue makes it an easily fixed one, through technological fixes and simple economic solutions (Hoyer, 2010). This singular focus on CO2-emissions within the issue of climate change has been conceptualized as 'CO2-reductionism' and can be defined as a form of reductionism in which the complex problem of climate change is reduced to one single aspect of the problem, namely CO2 emissions (Hoyer, 2010). An important concept linked to CO2-reductionism is 'neoliberal capitalism'. Neoliberal capitalism can be defined as the dominant political economy in the Western world. Neoliberalism refers to ideas of a free-market economic system, privatisation, deregulation with and a restrained role for the government. Moreover, neoliberalism promotes the idea of the market as a beneficial model for other domains of life such as the social, political and environmental (Harvey, 2005). The essential definition of capitalism "the motive to make profit" through privately owned assets and a free-market that allows for capital accumulation (IMF, n.d.). In the following chapter, neoliberal capitalism is used to refer to the desire for continuous growth, a restrained role of the government and the ever growing power of large corporations.

One may wonder what exactly the shortcomings are with the CO2-reductionist view, since those who focus on reducing the CO2 emissions are 'at least doing something'. Two important drawbacks of the reductionist vision will be explained in the following paragraph. The first drawback of the singular focus on CO2-emissions concerns the marginalisation of other important variables climate change entails such as biodiversity, water quality, aesthetic values and spiritual dimensions of nature (Smith, 2018). Though the latter may sound a bit woolly, the spiritual and aesthetic dimension of nature can be important for people in order to develop a moral connection with nature. This in turn may result in a stronger relation between human and nature characterised by reciprocity and increased responsibility towards the natural world (Cooper et al., 2016). If, hypothetically, the world would become 'CO2-neutral' in a couple of decades, the world will be still left with the other variables which remained unaddressed. Water scarcity and depletion form a serious threat to future food production. The loss of biodiversity and degrading quality of soil will alike form a threat to food production (Smith, 2018). The second drawback of the reductionist view is that it is not able to solve problems but displaces them. The CO2-low alternatives to energy, food, consumption products etc. can and will entail new problems and unfold new crises. Take for example the CO2-neutral alternative of nuclear energy, which gained a lot of popularity the past decades. Nuclear energy might be a CO2-low alternative, but it forms the same, if not bigger, threat to the environment and our pre-existence (Swyngedouw, 2020). For a food-related example one could think of greenhouse cultivation and the images of the future circular greenhouses. Circular greenhouses might be able to tackle some of the problems within our current food system, they tend to ignore the social dimensions of our relation with food (Glastuinbouw Nederland, n.d.). What about the aesthetic value of nature and reconnecting with our food production? Circular greenhouses offer an exclusively technological solution to some dimensions of the current problem, but fail to take into account an holistic approach.

Another concept alike is what Klein (2014) has called 'magical thinking', which can be understood as a paradoxical way of thinking in which the proposed solution to the problem is the thing that has caused the problem itself. An example of this can be frequently found in the neoliberal capitalist way of thinking, in which continuous economic growth is presented as a remedy while it is also the cause of the same problem (Klein, 2014).

If the current approach to address climate change is not able to establish the much necessary changes, why do we continue to hold on to this reductionist view? Swyngedouw (2020) argues that this approach enables us to sustain civilization as we know it, namely one under the neoliberal capitalist system. Holding on to technological solutions enables us to continue making profits and sustain high levels of consumption. It gives us the idea that something is done without having to radically change our way of living nor consumption patterns. Besides this, Swyngedouw (2020) argues that the underlying multiple and complex relations of environmental changes are not acknowledged leading to a double reductionism. The first reductionism refers to the obscuring of the correlation between the dominating capitalist system and high output of CO2-emissions. The second reductionism refers to the consideration of CO2-emissions as the object-cause of concern which further obscures the role socio-economic relations and the capitalist system. Framing the problem and lifting it from its relevant context and causes enables

to continue 'business-as-usual' (Swyngedouw, 2020). As mentioned, one of the main underlying causes of the high CO2-emissions release is the obsession with high levels of economic growth which very much relies on the exploitation of fossil fuels. In this context, maybe even more important is to realize that our modern Western identities also rely on the production and consumption of fossil fuels, it allows us to have high mobility, a sense of freedom and agency. When giving up these 21st century 'luxuries' means to lose a very essential part of our current identities and breaking the attachments to our current ways of living. However, breaking attachment involves facing the pain of loss and a process of mourning in order to let go of the present and embrace a 'new' future. In order to avoid this pain we engage in a process of disavowal (Fletcher, 2018). The concept of disavowal has its roots in the study of psychoanalysis and refers to the process of "simultaneously acknowledging and denying our ties and the pain this causes" (Fletcher, 2018, p. 49). Disavowal is a state of half-knowing, it suggests "I know very well, but still..." (Zizek, 1989, p. 12). This phrase must sound familiar to many people, 'we know taking the car instead of public transport is bad for the environment, but still'. 'We know smoking and drinking is bad for our health, but still'. To find a context related comparison, 'we know very well that switching to CO2-low food product alternatives is not enough, but still, at least we are doing something'. The failure of the current system to address the roots of the problem suggests that we need to hit the bottoms of oil reserves and stand eye-to-eye with the consequences of climate change before effectively addressing the problem. Besides this, it suggests that we are too much attached to our luxuries and growth to make any dramatic changes necessary to develop a sustainable world (Fletcher, 2018).

One could argue that this phenomenon is also visible in the struggle for people to switch to a sustainable diet. We are dealing with high complexity and untransparent information on our food sources, consumers are provided with 'easy' tools and alternatives. While Prepit clearly attempts to provide consumers with transparent information on their food products, it must prevent itself from being an 'easy-fix'. Such an 'easy-fix' does not represent the complexity of the problem, and it is precisely this complexity and its understanding that is necessary for the much needed change. Switching a handful of ingredients to low CO-eq alternatives provides the consumer with the idea they are making a contribution, while the total impact of these changes remain limited. The truth however uncovers that this is not enough, painful as it is, we must break attachment with our current high levels of consumption and dietary patterns.

Taking all this information and critical notes into account, one may wonder what kind of alternatives can be proposed that do address the roots of the problem. The next subquestion proposes two different alternative approaches which are both focused on issues within the food system.

4.3 How can the complex issue of social and environmental impact of commonly consumed products be translated in a clear overview for consumers?

In order to provide Prepit a practical tool to move beyond CO2-reductionism, three food passports have been created. These food passports are based upon a framework which can be used to analyse the level of sustainability of individual food products. This framework will then be used for creating three food passports for the following food products: bananas, avocados and apples. The framework will be based on the determinants provided under the 'sustainable diets' approach. The determinants of the 'sustainable diets' approach are originally selected for analysing sustainable diets as a whole. Due to the holistic view it uses, the sustainable diets approach will be used as the basis for the new framework which can be used by Prepit to assess the sustainability of food products. This new framework will contain a selection of the original determinants based upon the relevance for an individual product analysis.

Figure 12 contains the relevant determinants which influence the level of sustainability of individual food products. The chosen determinants attempt to cover a food product's 'passport' from 'farm to fork'. While Prepit attempts to focus their advice on the production process from 'cradle to retail', this framework attempts to take all relevant determinants for a food product's sustainability into account and therefore extended the analysis from retail to fork. In the former question the relevance of the different determinants have been justified. Certain determinants have been left out in this new framework if they were found to be irrelevant. The dimension of 'well-being, health' has not been integrated in the new framework since it concerns the composition of a diet as a whole and is not relevant to assess the sustainability of an individual product. Most of the determinants concerning the dimension of 'cultural heritage, skills' have also been left out since they do not provide relevant information for the individual level of analysis. The determinants of skills and 'knowledge of preparation' are integrated in the new framework, since it is argued that these can contribute to sustainable use of food products (Johnston, Fanzo & Cogill, 2014). In

the food passports this can take the form of tips on the use of the food product such as which parts you can eat or contain most vitamins or nutrients. Besides this, tips on the storage of the food product will be provided.

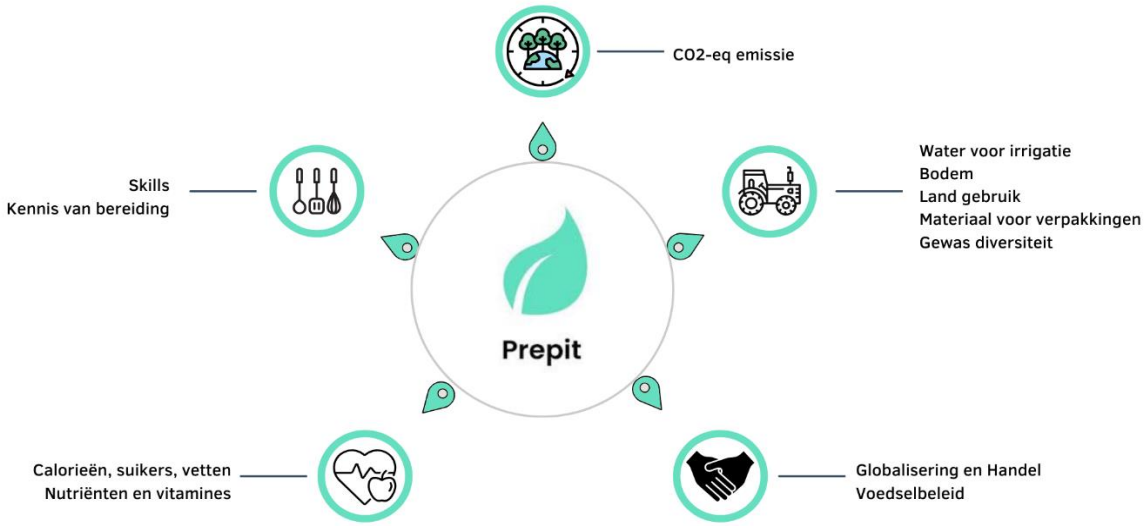


Figure 12: Framework 'sustainable food products'

Finally, the determinant of ecosystem services has been left out since this is a complex concept, it is beyond the scope of this report to address and does not lend itself as an accessible determinant to use for an individual product analysis. The framework uses the Dutch language so it can be used for the Prepit platform. When taking the information on reductionism and relevance of an holistic approach into account, a 'food passport' is suggested as fruitful alternative. A food passport contains information of a food product that are of influence on its level of sustainability. The chosen determinants may vary per food product since it is dependent on the information available and level of influence. The food passport does not suggest whether a product is 'good' or 'bad' but leaves this decision to the consumer. As argued, there are many factors of influence on the level of sustainability of a food product, not just CO2. A food passport complements this with available information on the different determinants of figure 2. The food passport aims to provide the consumer insights into the complexity of the issue of food and environment. Every food product has its own pluses and minuses and the food passports enables the consumer to make their own trade-offs when choosing a product. In what follows, a food passport will be presented of bananas, avocados and apples. Both bananas and avocados are popular food products and are often presented as 'sustainable' choices. However, both food products have some serious shortcomings when taking the other relevant determinants into account. The food passports have been made in Dutch as a realistic example of how such an holistic analysis can be used by Prepit to share on it's platform. In what follows, the background information used for the food passports will be outlined. The food passports can be found below.

BANANA

MONOCULTUUR
Bananen worden verbouwd in monoculturen. Dit zorgt voor landdegradatie en vergroot de kans op ziektes en schimmels.

DIVERSITEIT
Er is maar één soort banaan geschikt voor export. De bananenziekte 'panama disease' vormt een groot gevaar voor het voortbestaan van deze enige exporteerbare soort.

BESTRIJDINGSMIDDELEN
Monoculturen en het gebrek aan genetische diversiteit zorgen ervoor dat er enorm veel pesticiden worden gebruikt tijdens de teelt.

WATER
Bananen houden van veel en frequent water. Per land van herkomst verschilt het gebruik van 'blauw' irrigatie water.

BOEREN
Veel boeren verdienen minder dan het minimumloon, maken lange werkdagen en werken onder slechte arbeidsomstandigheden.

CO2
Bananen kennen een relatief lage CO2-uitstoot, wat onder andere komt doordat ze per schip worden vervoerd.

GEZOND
Bananen zitten vol voedingsvezels en zijn rijk aan kalium, zetmeel, vitamine B6 en vitamine C.

Biodiversity, environment, climate

The primary production stage of bananas have a relative low CO2-eq output. The use of fertilizers however makes up 24% to 49% of the total CO2-eq emission of a banana. Bananas are mostly transported by boat which is one of the most sustainable ways of transport, as discussed in chapter 1. Transport and storage account for 62% to 67% of the total CO2-eq of bananas (FAO, n.d.-a).

Equity, fair trade

On average, a banana farmworker earns between the 5% and 9% of the total value of bananas, compared to 36% to 43% of the revenue which is captured by retailers (MakeFruitFair, 2015). This unequal distribution of the revenue is partially due to the increasing power of supermarkets who are now, for several years already, engaged in a price war. The low retail prices go at the expense of the environment and working and living conditions of farmers (Madeley, 2008). Many farm workers earn less than the minimum wage while making long working days. Besides this, they often need to work unprotected with heavily toxic agrochemicals which endanger their health (MakeFruitFair, 2015).

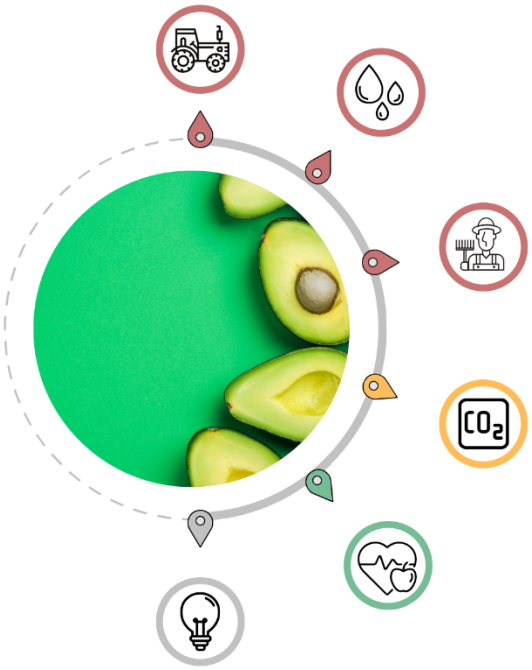
Eco-friendly, local, seasonal foods

Bananas need adequate and frequent watering. The use of irrigation water however, depends on the country of origin. The water footprint of bananas from Costa Rica is 100% green and do not require irrigation. Bananas from Peru are dependent of irrigation water and have a water footprint consisting of 94% blue water (FAO, n.d.-b). While there are more than 1000 varieties of bananas, there is only one sort which lends itself to be used for export, the cavendish banana. The cavendish is known for its enhanced fruit quality, disease resistance and good transportability. The cavendish banana accounts for 47% of the global production of bananas (FAO, 2020-c). The lack of diversity however makes the cavendish highly susceptible for two main diseases, namely the panama disease and black sigatoka. The panama disease is a soil fungus which could destroy an entire banana farm and leave the soil infected for several decades. The panama disease therefore threatens the future supply of export bananas (Wageningen University, n.d.). In order to successfully cultivate bananas a high use of chemical fertilizers is necessary. In fact, the banana industry is the second biggest consumer of chemical fertilizers (Bananalink, 2019). This is largely due to monoculture production without crop rotation which makes the fruit more vulnerable for pests and diseases (Lunder, 2014). The high use of pesticide poses a threat to the surrounding environment and unprotected farmworkers (FAO, n.d.-d).

Foods and nutrient needs, food security, accessibility

Bananas are rich in fiber, potassium, starch, vitamin C and vitamin B6. Besides, bananas are low in cholestrol, sodium and saturated fats (Nutrition Data, n.d.). With its approximate 95 calories per banana, it contains the most calories among the most popular Dutch fruits (Voedingscentrum, n.d.-g).

AVOCADO



MONOCULTUUR
Avocado's worden verbouwd in monoculturen. Dit zorgt voor landdegradatie en vergroot de kans op ziektes en schimmels. Door deze grote kans op ziektes worden er ook meer bestrijdingsmiddelen gebruikt.

WATER
Avocado's zijn echte waterslurpers en bevinden zich in de top drie van gewassen die waterschaarste veroorzaken. De grootte van de water voetafdruk hangt van waar de avocado vandaan komt.

BOEREN
De avocado hype zorgt voor een stijgende productie van avocado's in Zuid-Amerika. Dat zorgt voor economische voordelen, maar in Mexico zijn er criminele bendes betrokken en wordt de productie gekenmerkt door moderne slavernij en kinderarbeid.

CO2
Avocado's hebben ten opzichte van andere groente- en fruitsoorten een gemiddelde CO2-voetafdruk.

GEZOND
Avocado's zitten bomvol 'goede' vetten en proteïne. Ze zijn rijk aan vitamine A, B, D en E. Met 358 calorieën per avocado is het ook nog eens een vullende vrucht.

DUURZAAM GEBRUIK
Een halve avocado over? Deze kan je ook het beste in de koelkast bewaren, en het liefst in een herbruikbaar bakje.

Biodiversity, environment, climate

For a fruit sort, avocados have a relatively high CO2-eq output (RIVM, 2019-a). While most avocados are transported per boat, the Netherlands is the largest importer of avocados by air (Schiphol, 2018). To claim an avocado has a relatively low CO2-eq output it is important to know by which mode of transport avocados have been transported.

Equity, fair trade

The consumption of avocados has become more and more popular, and the world market has been growing continuously (FAO, 2004). Worldwide, Mexico is the largest producer of the avocado (Duarte, Chaves, Borges, & Mendonça, 2016). The growing market has brought along economic benefits for Mexico, since it substantially increases the availability of jobs (Dorantes, Parada, & Ortiz, 2004). However, at the same time, it caused crime groups to get involved, too. Modern slavery and child labour have increased, as well as violence and killings (Dehghan, 2019).

Eco-friendly, local, seasonal foods

Avocados are known for their high water footprint. They are one of the top three crops that cause water stress in their production region. The production of avocados entails water scarcity of a specific region and high levels of irrigated water needed for the yields (Stoessel, Juraske, Pfister, & Hellweg, 2012).

Avocados are grown as a monoculture. The same crop (trees) are grown on the same ground, for many years consecutively. Monoculture production causes the soil to be less nutritious and vulnerable to diseases, which means that more pesticides and fertilizers are needed (Gonçalves, 2018).

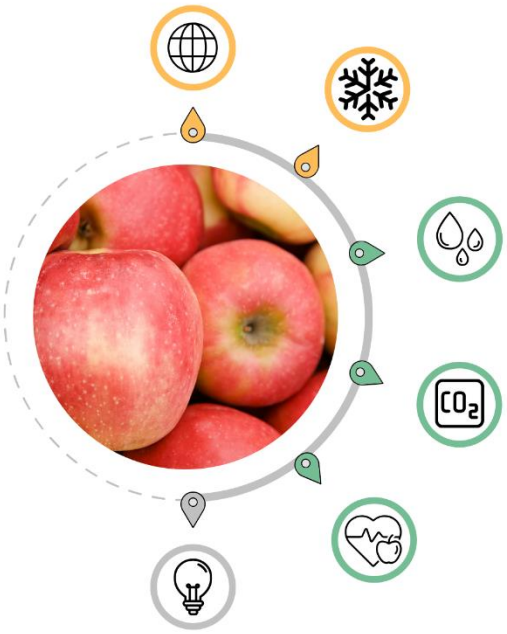
Cultural heritage, skills

Avocados are difficult to time, since they can quickly turn from unripe to overripe. Once an avocado is ripe, it is recommended to keep it in the fridge, since that will prevent it from going overripe (Waygood, 2019). Besides, when an avocado is cut open, the process of decomposition will go much faster. Therefore, it is also recommended to place cut-open avocados in the fridge. When an avocado is not ripe yet, the process can be fastened by placing it in a brown paper bag. The ripening process will go even faster when the avocado is placed in a brown paper bag together with another ethylene producing fruit, for example a banana (Waygood, 2019).

Foods and nutrient needs, food security, accessibility

An average avocado (180g) contains 358 kcal, which is higher than most other fruits and vegetables. An avocado contains 35,1g of fat, of which most is considered healthy: only 4g is saturated fat (Voedingscentrum, n.d.-g). Besides, it has quite a lot of protein and (fat soluble) vitamins that are generally not existent in other fruits, such as vitamin A and B, D and E. Avocados are recommended when following a healthy diet, since it helps reducing cholesterol levels and it lowers the chance on cardiovascular diseases (Duarte, Chaves, Borges, & Mendonça, 2016).

APPLE



GLOBALE TEELT
Appels komen tegenwoordig niet allemaal meer uit Nederland. Zo worden er bepaalde soorten zoals de Pink Lady's, Kanzi en Golden delicious uit Brazilië of Nieuw Zeeland geïmporteerd.

SLAPENDE APPELS
Appels in Nederland kunnen alleen worden geoogst in Oktober. Het overgrote deel van de oogst wordt 'in slaap gebracht' in speciale koelcellen. Wanneer er weer vraag is, worden deze appels weer wakker gemaakt.

WATER
Het telen van appels vraagt relatief weinig water.

CO2
Appels uit Nederland hebben een relatief lage CO2 uitstoot. Er komen, over het algemeen, weinig verpakkingssoorten aan te pas en er is relatief weinig CO2-uitstoot tijdens de transport.

GEZOND
Appels bevatten veel kalium en zijn een bron van veel voedingsvezels. Een gemiddelde bevat 56 calorieën.

DUURZAAM GEBRUIK
Laat de dunschiller de volgende keer maar liggen: de schil van appels zit bomvol voedingsvezels en vitamine.

Equity, fair trade
While most of the apples in Dutch supermarkets are from the Netherlands, an increasing number of apples are imported from foreign countries such as Argentine, Chile, Brazil, South Africa and New-Zealand. Most of these apples are transported by boat, which is a relatively sustainable form of transport. Consumption of apple with New-Zealand as country of origin are discouraged since they have a higher environmental footprint (Voedingscentrum, n.d.-h).

Eco-friendly, local, seasonal foods
It is argued that both apples from the Netherlands as well as other European countries are a sustainable choice all-year-round. Dutch apples are harvested around autumn but are all-year-round available for consumption (Voedingscentrum, n.d.-h). The surplus apples are stored in controlled atmosphere cooling cells and are brought 'to sleep'. When leaving these cooling cells the apples are being brought 'alive' again and will be ready again to be sold as fresh apples (Westra, n.d.; Rogers, 2012). Despite the energy consumption of storage in these controlled atmospheres it is argued that this is more sustainable when compared to importing apples from foreign countries (Voedingscentrum, n.d.-h).
Cultivating apples requires a relatively low land and water use. Besides this, the CO2-eq emissions of cultivating apples are also considered to be low (Voedingscentrum, n.d.-h)

Cultural heritage, skills
The peel of the apple contains many vitamins and is rich in fibers (Voedingscentrum, n.d.-i).

Foods and nutrient needs, food security, accessibility
Apples are a source of dietary fibers and are rich in potassium and antioxidants. Apples contain relatively low calories, an average apple contains 56 calories (Voedingscentrum, n.d.-h)

5. CONCLUSION

This report aims to answer the question '*What knowledge is needed for Prepit to contribute to reducing the CO2-eq emissions of the Dutch diet?*'. The results and accompanying opinions are divided into three main topics as described below.

Firstly, resulting from the research performed to evaluate the possibility of calculating scores for CO2-eq emission for different products, Prepit needs to know that it is not possible yet to give concrete, hard numbers on a certain product's CO2-eq emission. The methods to calculate an LCA are still quite uncertain and due to the complexity of the calculation and the multiple factors involved, we can, at this moment, only use the numbers as an indicator. However, the numbers can be used as an indicator for the comparison of different food categories and different recipes. At this moment, it is more important to concentrate on the different factors that are identified for estimating the CO2-eq emissions of a product, than to focus on numbers. These factors can be used as a tool to get an a proper idea of the environmental impact of a certain product.

The factors described in this paper are:

- Greenhouse horticulture or open ground cultivation. Here applies that open ground cultivation is generally lower in CO2-eq emissions than greenhouse horticulture cultivation.
- Seasonality. It is preferred to consume food products in season, either in the Netherlands or in other (nearby) countries.
- Storage. The amount of cooling increases the CO2-eq emissions.
- Transportation. Hereby, transport by water or road is preferred to air transportation.
- Packaging. The CO2-eq emissions for the packaging materials plastic and glass are lowest if they are fully recycled.

Resulting from the survey conducted for this report, Prepit can use the specific data about the eating behaviour of the community to personalise the information Prepit is providing. The use of more customised information can lead to a greater impact of the platform on the Prepit community.

Secondly, for Prepit, it is crucial to realise the importance of effective ways to achieve behaviour change towards a more sustainable diet. It is important for Prepit to focus on tackling the barriers consumers are facing, namely wealth and status, a lack or overload of information, perceived price, habits, and the perceived individual impact.

Finally, it has been found that the problem of climate change should not be reduced to CO2-eq emissions alone since the problem is more complex than this. While it is tempting to simplify the problem, it could prevent any effective change from happening. For Prepit this means that the following other dimensions of sustainability must be taken into account:
food nutrients, biodiversity/environment/climate, equity/fair trade, eco-friendly/local/seasonal, and cultural heritage/skills. These dimensions and their relevant determinants are adopted in the framework for sustainable food products, which can be used by Prepit as a guideline for analysing a food product's sustainability.

Altogether, Prepit is, despite the complexity of the issue, on the right track to supply reliable information to its community. The recommendations described in the next section of this report can be used to increase the reliability of the information provided, and to increase the change on lasting behavioural changes among the community.

6. DISCUSSION

The following paragraphs entail some important points of discussion. The complexity of CO2-eq emissions of food products has been established by now. However, in order to interpret the results correctly, nuances should be made.

Firstly considering the method, using expert interviews can give very detailed and precise information about the topics. However, on the other hand, the information provided by a hand full of experts is also limited and can be one-sized and biased by personal attachment with a topic. Furthermore, the team consists of experts in the fields of Nutrition and Health, Health and Society, and International Developmental studies. This expertise can provide a new perspective on the topic by, for example, introducing the importance of nutritional value and the social aspect of the problem. However, on the other hand, the team might lack some basic knowledge on the specific topic of environmental impact and the processes at play. Nevertheless, we are all academic master educated, and therefore it can be assumed that we have a scientific approach in dealing with scientific issues and using information in an academic manner.

For the literature search, the snowball method was used. This method is suitable when studies are difficult to find, and when limited time is available. However, a disadvantage of this method is that more relatively older articles are found. This is especially detrimental for disciplines where innovations are developed fast (Hogeschool Rotterdam, n.d.).

To continue, it is important to discuss the following topics: the nutritional value of foods, the healthiness of the diet, the limited impact one individual can have and the limited impact of a focus on fruits and vegetables.

Nutritional value and LCA

Traditionally, environment and nutrition have been considered to be two separate fields of research. However, since awareness of the impact on the climate of the diet and individual food products has increased in recent years, those fields of research are integrating bit by bit in policy, society and research as well (Nemecek et al., 2016). This growing acknowledgment of the relation between both health and environmental effects contributed to the enormous growth of the research area exploring methods to combine these two fields (Mertens et al., 2017).

With LCA, the environmental performance of a (food) product can be assessed (Satpute et al., 2013), aiming to provide relevant information about the different environmental impacts which are associated with the (food) product (Saarinen et al., 2017). These environmental impacts are assigned to FU, which quantifies the performance of a product for use (ISO, 2006). Currently, the environmental impact of food is generally determined on a weight basis, according to Schau & Fet (2007). This indicates that nutritional functions are not taken into account at the moment. The inclusion of nutritional value into LCA may impact conclusions and recommendations. For example, food products with low dietary quality and with a low life-cycle impact, will not be recommended for the population when targeting the total sustainability. An example of such a product are crisps, since by consuming crisps, it is possible to have a diet low in CO2-eq output, but still have an unhealthy diet (Macdiarmid, 2013).

To incorporate nutritional value into LCA, there are two approaches according to Saarinen et al. (2017). The first approach focuses on individual nutrients of food products. However, this approach is in practice not applicable to discriminate between sustainable and unsustainable food products. This is due to the fact that individual nutrients vary enormously and randomly. Nevertheless, this approach may be useful to consider the relative environmental impact of food products when nutrients are scarce or sources are limited. The second approach gives a more general overview. For this reason, this approach may be useful for food LCA to take nutritional value into account. But, since there is not a golden standard method for this approach yet, nutritional value is not incorporated into the data used in this report. However, it is important to do so in future reports, but for this further research is needed. On top of that, only the amount of a product needed to fulfill a nutritional need is incorporated into this approach (Saarinen et al., 2017). However, the importance of a diverse diet, including a large diversity of nutrients, is not taken into account. For this reason, only a distinction can be made on product level between products high and low in beneficial nutrients.

Health and sustainable diet

As described above, integrating advice on reducing the environmental impact while taking the nutritional values into account, increases the complexity of the LCA. A healthy diet is not necessarily associated with a lower CO2-eq. However, research shows that it is feasible to compose a realistic diet which both has a

lower CO2-eq output and meets the nutritional requirements (Macdiarmid, 2013). This research showed it was achievable to meet recommendations for energy and macro- and micronutrient intake, while reducing the CO2-eq output with approximately one third. Macdiarmid (2013) suggested that it is important to reduce the consumption of meat and dairy consumption and to reduce overconsumption. These are dietary changes that could benefit both health and the environment. In a study conducted from 1961 onwards, it has been shown that the demand for so-called "empty calories" has increased (Tilman & Clark, 2014). In nutrition research, the term empty calories refers to the energy from food containing no beneficial nutrients (Cambridge Dictionary, n.d.), for example, crisps which consist mostly of fat and do not contain many beneficial nutrients. The inclusion of the nutritional value in LCA of food products could help point out which foods should still be avoided despite their low CO2-eq, since the consumption of "empty calories" is disadvantageous both for emissions as for human health. The consumption of empty calories is associated with overconsumption, which can be seen as a form of food waste (Macdiarmid, 2013). So, overconsumption is associated with higher CO2-eq emissions. Another example concerning healthy and sustainable nutrition regards the consumption of processed and unprocessed red meat. Red meat products are associated both with the largest environmental impacts and the biggest increase in disease risk (Steenson & Butriss, 2020). So, even though a healthy diet is not necessarily environmentally friendly, there are similarities between the guidelines for healthy nutrition and the advice for reducing the CO2-eq of the diet.

Individual impact

Another point of discussion is the fact that the individual impact of the whole aspect of sustainability might actually be somewhat low. In sub question 2, it was mentioned that people often have the idea that they are not able to contribute to a better (more sustainable) world, and that this can be perceived as a barrier for adapting a sustainable diet. In order to motivate people, they should be given the feeling that they are able to make a contribution. This is the case when looking at factors such as footprint and water use. An example of this is mentioned in sub question 2, where it appeared that by choosing the vegetarian burger rather than meat, one can considerably contribute to a reduced footprint and water use. However, when taking sub question 3 into consideration and by acknowledging that the issue of sustainability is way more extensive, and that other factors (e.g. wasting management and deforestation) are also of great importance. In that sense, it can be difficult to comprise all of these factors when making individual choices. Therefore, when aiming to educate people correctly, it might not be possible to give them the feeling that they can make an overall individual contribution.

Impact fruit and vegetables

Furthermore, it has been established that (red) meat has a substantially higher level of CO2-eq emission, compared to fruits and vegetables (RIVM, 2019-a). Therefore, one could argue that promotion of a sustainable diet should be focused on reducing meat intake. Also, our expert interviews have indicated that the primary principle should be to reduce one's meat and dairy consumption and to promote plant-based substitutes. However, the environmental impact of meat is also generally more widely known among consumers already. The target group of this study, the Prepit community, has shown to have a reduced meat intake compared to the Dutch population as a whole. The Prepit community generally consumes more plant-based alternatives to meat compared to the average Dutch population. In contrast, the cheese consumption of the Prepit community is higher than of the Dutch population, and therefore it seems the largest difference in reducing CO2-eq emissions can be obtained by focusing on cheese consumption. All in all, it is argued that a focus on meat and dairy consumption is much more efficient in lowering the CO2-eq emissions of the diet than a focus on fruits and vegetables.

7. RECOMMENDATIONS

Based on the conclusions from literature, interviews with experts, and our own expertise, we recommend Prepit the following:

- Compare various food categories instead of specific food products. Because of the use of bandwidths in calculations, it is more reliable to compare food categories.
- When using data for the comparison of food categories, use one source only. Data from different sources can't be compared because the methods applied can vary enormously.
- Conduct once in a while surveys among the Prepit community in order to get insight into their eating patterns and target group characteristics, for example via Instagram stories. This can be useful for providing appropriate recipes and suitable messages to the Prepit community.
- For factors that are included in the food supply chain, some recommendations are put forward:
    - Promote, if the knowledge is available, seasonable food products from open ground cultivation.
    - Promote products that are transported by boat and road traffic, since this is preferred to air transport.
    - With regard to packaging, mainly focus on promoting PET and glass material that is completely recyclable since this type of packaging has the lowest environmental impact.
- When available, from Juli 2020 onwards, make use of the PEF-calculator (Product Environmental Footprint).
- With regard to the outcomes of the survey, multiple recommendations can be given:
    - Take initiative to tackle the high amount of cheese consumed by the Prepit community.
    - Promote the intake of nuts among the Prepit community since it turned out that this is not eaten much yet.
    - Promote legumes because they are not consumed at all by the Prepit community.
    - Focus on promoting sustainable meat substitutes, since meat substitutes are highly consumed among the target group.
- To accomplish behaviour change, several recommendations can be proposed:
    - Induce a positive attitude about sustainable products by mentioning its values and benefits.
    - Provide tips and/or suggestions for food switches that are easy to implement; make sustainable alternatives as easy as possible so that habits can be overcome.
    - Emphasize that sustainable food is not expensive so that the perceived price of a sustainable diet is low(er).
    - Develop a standard label that expresses the ecological footprint for a certain food product/dish in the form of a traffic light.
    - Include the health aspect in their recommendations on sustainable food products because sustainable food products are often considered to be healthy too.
    - Make Prepit accessible for every gender.
    - Provide information on food waste and loss.
- In order to communicate effectively, the following should be taken into account by Prepit:
    - Identify the target group characteristics so that communication will be as effective as possible.
    - Use a gain frame, positive emotions, and focus on what somebody can do to reduce their individual contribution to climate change.
    - Remain focus on the target group of environmentally conscious consumers.
    - Emphasize that certain outcomes can be avoided, by feasible actions.
- Be aware of the fact that sustainability is about more than CO2 emissions, and that a vegetable or fruit low in CO2-eq is not necessary a sustainable product.
- Focus on the reduction of meat and dairy rather than switching between different fruits and vegetables, since this will lead to a larger reduction in CO2-eq emissions.
- Recommend sustainable products that have a low calorie density and a high nutritional value to prevent over consumption and overweight.

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APPENDIX A: DUTCH DIETARY PATTERN BASED ON DNFCS 2012-2016;RIVM

Commonly consumed product per food group average Dutch population

About the Dutch National Food Consumption Survey

The Dutch National Food Consumption Survey (DNFCS) has been conducted periodically since 1987 (RIVM, 2020). It maps the diet of the Dutch population and it is amongst others used for scientific research. This report uses the results of the DNFCS of 2012 until 2016, which is the most recent survey (RIVM, 2019). The study population consisted of children and adults between the ages of 1-79 years old, who live in the Netherlands. The data was collected via 24-hr dietary recalls on two not contiguous days. These 24-hr recalls were performed via interviews by phone. For children between 1 and 3 years of age, the parents/caretakers were interviewed and also food diaries were recorded. Children from the age of 4 to 15 years were interviewed at home with their parent(s)/caretaker(s) present. Furthermore, the elderly were also interviewed at home. The DNFCS 2012-2016 (RIVM) uses the following food group categories mentioned in table 16.

Table 16: food group categories DNFCS 2012-2016;RIVM

Potatoes	Fats and oils
Vegetables	Sugars and confectionery
Legumes	Cakes and sweet biscuits
Fruits, nuts, and olives	Non-alcoholic beverages
Dairy (products)	Alcoholic beverages
Cereal (products)	Sauces and seasonings
Meat (products)	Stocks
Fish and shellfish	Savory snacks
Egg (products)	-

As the categories of the DNFCS are quite elaborate, the results of the DNFCS 2012-2016 will be summarized in this report according to the categories classified by the Dutch Wheel of Five, which is used by the Netherlands Nutrition Centre (Brink, Postma-Smeets,Stafleu & Wolvers, 2017). These categories are:

1. Bread, grains/cereal products and potatoes
2. Dairy, nuts, fish, legumes, meat and eggs
3. Spreading and cooking fats
4. Drinks
5. Fruit and vegetables

The Wheel of Five is a guide to a healthy and varied diet, however, this overview will not specifically focus on the nutrient content and healthiness of the products. It is merely used as a more comprehensible overview.

1.Bread, grains/cereal products and potatoes

Bread

On average, Dutch people consume 3,5 slices of bread/day (males 146 g/day; females 104 g/day).

Grains/cereal products

On average Dutch people, men and women, consume 7.4 grams of breakfast cereal products/day. The DNFCS 2012-2016 (RIVM) further summarizes pasta, rice, and grain products in one category. The Dutch population consumes 47.1 grams of products in this category (males 55.3 g/day; females 38.8 g/day).

Potatoes

The category potatoes of the DNFCS 2012-2016(RIVM) includes potatoes, potato products, and tuberous plants (like the sweet potato). On average, Dutch people consume 72 grams of potatoes a day (males 84 g/day; females 61 g/day). Furthermore, potatoes are on average consumed 3,5 days a week.

2.Dairy, nuts, fish, legumes, meat, and eggs

Dairy

According to the DNFCS 2012-2016 (RIVM), on average 352 grams of dairy products a day are consumed in the Netherlands. The most consumed dairy products are milk (42%), yoghurt (15%) and cheese (9%). From a total of 352 grams of dairy products a day, 8.4 grams consists of dairy replacement products (2.4%). Women consume on average 10.6 g/day and men 6.2 g/day of dairy replacement products.

Nuts

In the DNFCS 2012-2016 (RIVM) nuts are categorized together with fruits and olives. There are several categories for this group of food products, which are: fruit and nuts mixed; fruit; fruit compote; nuts and seeds; peanut butter, nut butter; olives. To determine the average intake of nuts in the Dutch population only the categories fruit and nuts mixed, nuts and seeds and peanut/nut butter are taken into consideration. On average 10.1 g/day of nuts are consumed (males 12.4 g/day; females 7.7 g/day). What has to be taken into account here, is that this number also includes seeds and a small portion of fruit (e.g. mixed nuts and raisins).

Fish

According to the DNFCS 2012-2016 (RIVM), on average 16 g/day of fish is consumed in the Netherlands (males 17g/day; females 16 g/day). This includes fish, fish products, shellfish and crustaceans. On average 42% of the fish consumed consists of fatty fish. According to the dataset of the RIVM (Personal communication, June 11, 2020), the most consumed type of fish during dinner is farmed salmon, prepared in the microwave oven (on average 1.8 g/day). The second most consumed type of fish at dinner is fish fingers unprepared (1.2 g/day).

Legumes

This category includes peas and beans (e.g. split peas, green peas, chickpeas, soybeans, kidney beans, capuchins). On average Dutch people consume 5 grams of legumes a day (males 4.6 g/day; females 4.5 g/day).

Meat

On average, 98 grams of meat is consumed every day in the Netherlands (males 115 g/day; females 81 g/day). The DNFCS 2012-2016 (RIVM) has divided this category into the following subcategories: meat(products) other (7.9 g/day); beef (12.2 g/day); pork (13 g/day); poultry (16.4 g/day); processed meat for warm meal (26 g/day); cold cuts (21.1 g/day); meat substitutes (1.5 g/day). This shows that only a very small amount of meat substitutes is on average eaten a day. The most consumed types of meat at dinner are chicken fillet raw (9.5 g/day), minced meat (4.6 g/day) and hamburgers (3.3 g/day) (Van Rossum et al., 2018).

Eggs

For this category, eggs that are used in cakes or desserts are not taken into account. On average 13 grams of egg is eaten per day (males 13.7 g/day, females 11.6 g/day).

3.Spreading and cooking fats

The DNFCS 2012-2016 (RIVM) includes here all different kinds of spreading- and cooking fats for the warm meal and used on bread. It is divided into the subgroups: vegetable oil; butter; margarine and cooking oils; fats and oils other. Dutch people eat on average 22 gram of fats and oils a day (males 26 g/day; females 19 g/day). The subgroup of margarine and cooking fats contributes most (14.9 g/day) to the total amount of fats consumed.

4.Drinks

In the Dutch Wheel of Five, only healthy drinks like water and tea are considered, but as this overview does not have the nutritional value of the products as main interest also products groups that normally fall outside of the Dutch Wheel of Five are mentioned here.

Non-alcoholic drinks

On average Dutch people drink 1.7 liters of non-alcoholic drinks a day (males 1.6 L/day; females 1.8 L/day). This is subdivided in the following categories and the subsequent amounts: water, mineral water (588.7 mL/day); herbal and fruit tea (88.4 mL/day); tea (225.7 mL/day); coffee (392.5 mL/day); lemonade, soft drinks (349.3 mL/day); fruit and vegetable juices (55.4 mL/day); other non-alcoholic drinks (7.5 mL/day).

Alcoholic drinks

Dutch people drink on average 0.9 glasses (139 g) of alcoholic drinks a day (males 1.3 glasses/day; females 0.5 glasses/day). Beer (92 g/day) and wine (38 g/day) are the most consumed alcoholic drinks.

5.Fruit and vegetables

Fruit

As mentioned before, fruit is categorised in the DNFCS 2012-2016 (RIVM) together with nuts. To determine the average intake of fruit in the Dutch population only the categories fruit and fruit compote are taken into consideration. Dutch people eat on average 119 grams of fruit and fruit compote a day (males 108 g/day; females 130 g/day).

Over the period of 2012-2014 some of the data of the DNFCS was already summarised to see which fruits are most consumed in the Netherlands. According to the MEMO-VCP 18-01, apples (27.9 g/day) and bananas (20.8 g/day) are the most consumed types of fruit (RIVM, 2018). The

remainder of the top 10 consists of: **pears** (8.9 g/day), **tangerines** (7.4 g/day), **oranges** (7 g/day), **grapes** (5.4 g/day), **strawberries** (4.9 g/day), **kiwi** (2.6 g/day), **pineapple** (2.5 g/day) and **melons** (2.3 g/day). In total, this selection of fruits contributes to 80% of the total fruit consumption in the Netherlands.

As this data only summarizes the results of the first two years of the DNFCS, and the complete datasets of the total DNFCS 2012-2016 are not yet published online, RIVM was contacted in order to receive a copy of their data. From the dataset of RIVM the 10 types of fruit for which the mean intake per day (g/day) was the highest were selected. In table 17 data from table 5.1, "Consumption of fruit and vegetables of Dutch children and adults aged 1-79 years (DNFCS 2012-2016) weighted for socio-demographic characteristics season and day of the week (N=4313)" of the DNFCS, has been arranged (Van Rossum et al., 2018). As can be seen, the data changed slightly after the data of the remaining two years of the DNFCS was also collected and calculated.

Table 17: mean intake (g/day) of fruits

Type of fruit	Mean intake (g/day)
Apples*	29.2
Banana	24.9
Pear*	9.3
Mandarins	8.2
Orange	7.0
Strawberries	5.5
Grapes with skin (white; black)	5.4 (3.9;1.5)
Melon**	3.4
Kiwi green	2.6
Mango	2.2

*Sum of the mean intake (g/day) of these fruit types with and without skin

**Sum of the mean intake (g/day) watermelon, netted melon, honeydew melon and cantaloupe melon

Vegetables

On average Dutch people eat 131 grams of vegetables a day (males 129 g/day; females 133 g/day). The food group vegetables is subdivided in multiple sub-categories; stalk vegetables, sprouts; onion, leek, garlic; peas, corn, broad beans; mushrooms; cabbage varieties; tuber and root vegetables, fruiting vegetables, leafy vegetables and mixed vegetables. These food groups are quite broad and do not give detailed information for each type of vegetable individually.

Some results of the DNFCS 2012-2016 (RIVM) have already been published on wateetnederland.nl (RIVM, n.d.). Here an overview of the most consumed vegetables has been provided. According to this the following 11 vegetables were consumed the most in the Netherlands: **tomato** (20.2 g/day), **carrots** (10.4 g/day), **lettuce** (8.5 g/day), **cucumber** (8.4 g/day), **onion** (7.6 g/day), **green beans** (7.3 g/day), **vegetables for stir-fry** (6.5 g/day), **broccoli** (5.5 g/day), **spinach** (5.0 g/day), **cauliflower** (4.6 g/day) and **sweet pepper** (3.8 g/day) However, this data is also only from the first two years of the DNFCS (2012-2014). Therefore, the more detailed dataset of the RIVM (Van Rossum et al,. (2018) was consulted again. The data from table 5.1 has been arranged in table 18.

Table 18: mean intake (g/day) of vegetables

Type of vegetable	Mean intake (g/day)
Tomatoes	Total: 18
• *Tomato classic round* (raw + boiled)	11.1
• *Tomato vine* (raw)	3.1
• *Tomato cherry* (raw)	2.9
• *Tomato beef* (raw + boiled)	0.4
• *Tomato average* (raw + boiled)	0.5
Carrots	Total: 9.2
• *Carrot bunched* (raw + boiled)	4.4
• *Carrot winter* (raw + boiled)	3.9
• *Carrot average* (raw + boiled)	0.9
Cucumber (wo/w skin, raw + boiled)	8.4
Onions (raw + boiled)	7.6
Broccoli (raw + boiled)	5.5
Beans French (boiled + frozen, boiled)	5.9
Spinach (raw, boiled + frozen, boiled + cream, frozen, boiled)	4.9
Cauliflower (raw + boiled)	4.6
Lettuce	Total: 7.4
Lettuce iceberg (raw)	4.1
Lettuce average (raw)	0.8
Lettuce red (raw)	0.5
Lettuce romaine (raw)	0.2
Lettuce butterhead (raw)	1.5
Lettuce Lambs (raw)	0.3
Sweet pepper	Total: 3.8
Sweet pepper red (raw + boiled)	2.3
Sweet pepper green (raw + boiled)	0.4
Sweet pepper yellow (raw + boiled)	0.4
Sweet pepper average (raw + boiled)	0.7
Leek (raw + boiled)	3.6
Chicory (raw + boiled)	3.4
Mushroom (raw + boiled)	2.8
Courgettes (raw + boiled)	2.7
Endive (raw + boiled)	2.1

The numbers presented in table 18 do not include tinned, pickled or mixed products, or products processed in any other way other than boiling/cooking and freezing. As the data shown in table 18 is from the full four year period and we included only a selection of products, the data slightly differs from that already published online (RIVM, n.d.). Stir-fry vegetables are, for example, included in the graph of wateetnederland.nl, but as this is often a mix of vegetables it was not included in the top 15 most eaten vegetables in table 18. If we use the data from the dataset (2012-2016), which is the most recent, stir-fry vegetables are on average consumed 5.4 g/day. This value is lower than the 6.5 g/day that was reported after the first two years of the DNFCS (2012-2014).

Other

This includes product groups that do not belong in the Dutch Wheel of Five, but are a component of the Dutch diet.

Cakes and sweet biscuits

Dutch people eat on average 41 g of cakes and sweet biscuits a day (males 44 g/day; females 38 g/day). This consists of 24.1 g/day (males 25.9 g/day; females 22.3 g/day) of cakes, pies and pastries (e.g. ontbijtkoek). Furthermore, 17.1 g/day (males 18.2 g/day; females 15.9 g/day) of dry cakes and sweet biscuits is consumed.

Sugars and confectionery

On average, the Dutch consume 30 g/day (males 34 g/day; females 26 g/day) of sugar and confectioneries. In this category is included: sugar; jam, jelly, marmelade, other sweet spreads; honey; sweet sauce, sweet toppings for desserts, syrups; chocolate and candybars; chocolate paste, confetti/flakes; candy (not chocolate) and sweets other.

Savory snacks

Dutch people consume on average 21 g of savory snacks a day (males 25 g/day; females 16 g/day). This category includes pretzels, chips, salty biscuits and snacks like croquettes (kroketten) and savoury filled buns. There is also a subcategory with rest products like salted popcorn and banana chips. Chips, pretzels and salty biscuits are on average consumed 9.4 g/day (males 12 g/day; females 6.7 g/day). Snacks, croquettes and savoury filled buns are consumed on average 11.2 g/day (males 13.1 g/day; females 9.3 g/day).

Sauces and seasoning

On average 35 g of sauces and seasoning a day is consumed by the Dutch population (males 41 g/day; females 29 g/day). There are four categories: sauces and seasoning, other; tomato sauces; mayonnaise and dressing; mayonnaise based spreads. 16.3 g/day is due to sauces and seasoning, other (males 19.4; females 13.2).

Stocks

On average Dutch people consume 43 g of stocks a day (males 43.3 g/day; females 41.8 g/day).

APPENDIX B : SHORT SUMMARY OF RESULTS PER CATEGORY SURVEY PREPIT COMMUNITY

1. Bread, grains/cereal products and potatoes

Bread

4 out of 28 participants consumed bread in their reported dinner meal. The most consumed bread both in weight and frequency is hard white bread.

Grains, cereal products and potatoes

The most consumed food product both by weight and frequency in this category is potatoes, followed by rice and pasta. Potatoes were prepared in various manners. Only 2 respondents out of 11 who consumed rice or pasta reported having consumed the whole-wheat variant.

2. Dairy, nuts, fish, legumes, meat, and eggs

Dairy such as milk and yogurt

10 out of 28 participants consumed products of the dairy category. The most consumed dairy product in weight is semi-skimmed milk. The most frequently consumed dairy product is cream. One plant-based dairy substitute was consumed.

Cheese

12 out of 28 participants consumed cheese products. The most consumed cheese both in weight and and frequency is parmesan cheese. Dutch cheese (i.e. Gouda, Edammer) is consumed more frequently, but the quantities of Dutch cheese used in the meals was smaller than of most other cheeses. The category other cheeses consists of cheddar, white cheese, mozzarella and goat cheese.

Nuts and seeds

Only 4 out of 28 participants consumed nuts/seeds. All participants consumed different nuts/seeds. In weight, the largest consumption is of cashew nuts. Pine nuts, peanuts and walnuts are consumed in the same quantity.

Dairy, nuts, fish, legumes, meat, and eggs

Meat replacers are both in weight and frequency the most highly consumed products of this category. Lamb and minced meat are shared third place based on weight, but they are consumed with a frequency of one and two, respectively.

3. Spreading and cooking fats

Fats

The most consumed fat both in weight and frequency is oil. This is followed by “bak & braad” and finally butter.

4. Fruit and vegetables

Fruit

27 out of 28 respondents reported consumption of fruit. Apple is the most consumed fruit both by weight and frequency, followed by banana. Forest fruit and mandarin are in the top 5 of the most frequently consumed fruits, but not in the top 5 of the most consumed fruits by weight. Grapes and pear are in the top 5 of the most consumed fruits by weight, but not by frequency.

Vegetables

27 out of 28 respondents reported consumption of vegetables. Cucumber is the most consumed vegetable by weight. Tomato is the most consumed vegetable by frequency. Green salad and bell pepper are on the shared fourth place of most frequently consumed vegetables. Tomato, onion, cucumber and green salad are in the top 5 consumption both by weight and frequency. Green beans are in the top 5 of most consumed vegetables by weight, but not by frequency. Bell pepper is only in the top 5 of most consumed vegetables by frequency.

5. Other

Other products

In this category, a distinction is made in commonly consumed products. This lead to the formulation of the following subcategories: sauces, plant-based dairy and frozen meals. The subcategory ready-to-eat “frozen meal” contains the largest consumption weight, however, it is only consumed once. The frozen meal consumed was a frozen pizza. The most frequently consumed other products are products from the subcategory “sauces”, followed by coconut milk. Sauces consists of for example guacamole and mayonnaise.

Table 29: Top three fish, legumes, meat and meat substitutes consumption by weight

Top 3 (weight)
1. Meat substitutes
2. Fish products
3. Minced meat
3. Lamb

Table 30: Top three fish, legumes, meat and meat substitutes consumption by frequency

Top 3 (frequency)
1. Meat substitutes
2. Egg
3. Chicken
3. Fish

Table 31: Top three fat consumption by frequency and weight

Top 3
1. Oil
2. "Bak & braad"
3. Butter

Table 32: Top three nut consumption by weight

Top 3 (weight)
1. Cashewnuts
2. Pine nuts
2. Peanuts
2. Walnuts

Table 33: Top three nut consumption by frequency

Top 3 (frequency)
1. Cashewnuts
1. Pine nuts
1. Peanuts
1. Walnuts

Table 34: Top three dairy consumption by weight

Top 3 (weight)
1. Semi-skimmed milk
2. Whipped cream
3. Vanilla custard

Table 35: Top three cheese consumption by weight

Top 3 (weight)
1. Parmesan cheese
2. Mozzarella
3. Dutch cheese

Table 36: Top three bread consumption by weight

Top 3 (weight)
1. Hard white bread
1. Pita bread
2. Brown bread

Table 37: Top three bread consumption by frequency

Top 3 (frequency)
1. Hard white bread
2. Pita bread
2. Brown bread

Table 38: Top three cereal and potato consumption by frequency and weight

Top 3
1. Potatoes
2. Rice
3. Pasta

Table 39: Top three consumption of other products by weight

Top 3. (weight)
1. Coconut milk
2. Frozen meal
3. Sauces

Table 40: Top three consumption of other products by frequency

Top 3 (frequency)
1. Sauces
2. Coconut milk
3. Frozen meals

APPENDIX C: DETAILED RESULTS SURVEY PREPIT COMMUNITY

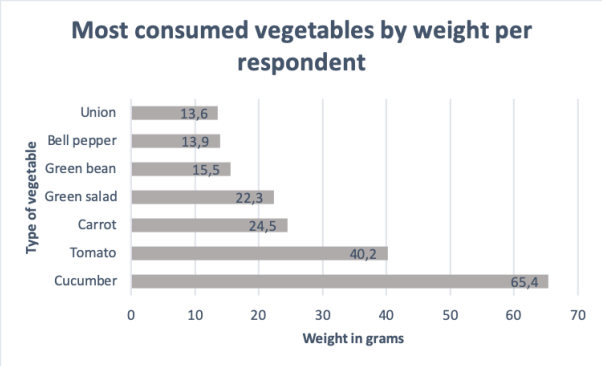

Figure 13: Most consumed vegetables by weight per respondent

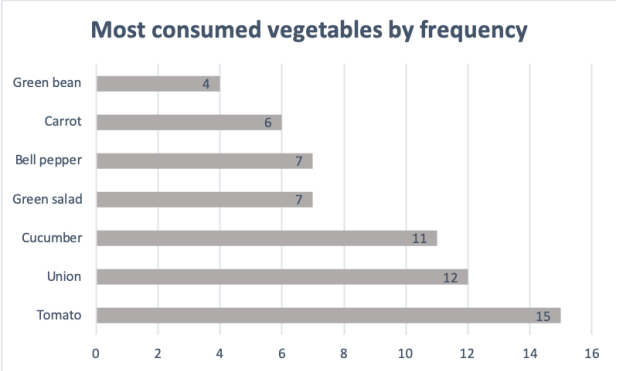

Figure 14: Most consumed vegetables by frequency

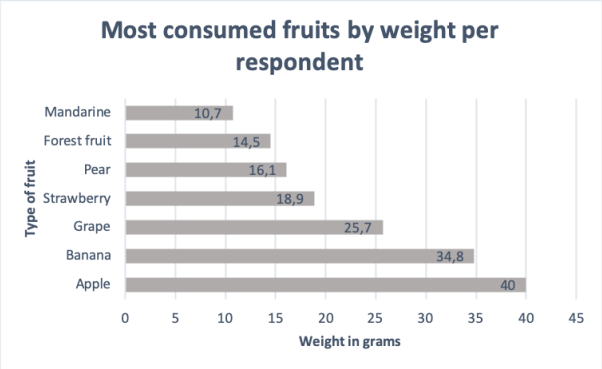

Figure 15: Most consumed fruits by weight per respondent

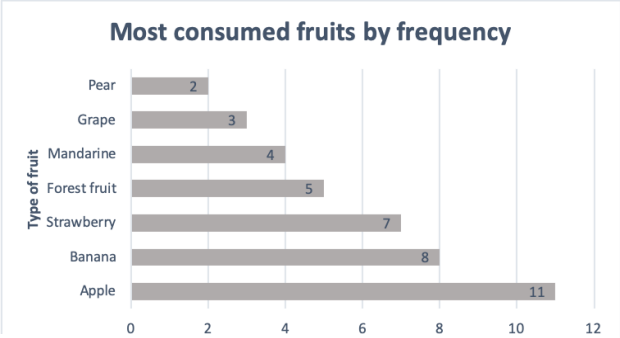

Figure 16: Most consumed vegetables by frequency

Table 41: Consumption of vegetables

Product	Consumers	Average consumption per consumer	Average consumption per respondent (g)
1830 g cucumber	11	166,4	65,4
1125 g tomato	15	75	40,2
685 g carrot	6	114,2	24,5
625 g green salad	7	89,3	22,3
435 g green beans	4	108,8	15,5
380 g union	12	31,7	13,6
390 g sweet pepper	7	55,7	10,4

Table 42: Consumption of fruits

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
1345 g apple	11	122,3	48
975 g banana	8	121,9	34,8
720 g grape	3	240	25,7
530 g strawberry	7	75,7	18,9
450 g pear	2	225	16,1
405 g forest fruit	5	81	14,5
300 g tangerine	4	75	10,7

Table 43: Consumption of fish, legumes, meat and meat substitutes

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
905 g meat substitutes	9	100,6	32,3
446 g fish products	3	148,7	15,9
300 g minced meat	2	150,0	10,7
300 g leg of lamb	1	300,0	10,7
280 g chicken products	3	93,3	10,0
225 g egg	4	56,3	8,0
200 g pork	2	100,0	7,1

Table 44: Consumption of fat

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
193 g oil	17	11,4	6,9
70 g "bak en braad"	3	23,3	2,5
27 g butter	2	13,5	1,0
2 g margarine	1	2,0	0,1

Table 45: Consumption of nuts

Product	Consumer	Average consumption per consumer (g)	Average consumption per respondent (g)
10 g pine nuts	1	25	0,9
25 g cashew nuts	1	10	0,4
10 g peanuts	1	10	0,4
10 g walnuts	1	10	0,4

Table 46: Consumption of dairy

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
425 g semi-skimmed milk	1	425	15,2
150 g whipped cream	2	75	5,4
150 g vanilla custard	1	150	5,4
80 g boursin	1	80	2,9
84,5 gr ice cream	2	42,3	3,0
40 g creme fraiche	2	20	1,4
20 g sour cream	1	20	0,7

Table 47: Consumption of cheese

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
265 g Parmesan cheese	5	53	9,5
62 g mozzarella	1	62	2,2
60 g Dutch cheese	3	20	2,1
50 g white cheese	1	50	1,8
15 g Cheddar	1	15	0,5
15 g goat cheese	1	15	0,9

Table 48: Consumption of bread

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
100 g hard white bread	2	50	3,6
100 g pita bread	1	100	3,6
50 g brown bread	1	50	1,8

Table 49: Consumption of cereal products and potatoes

Product	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
1970 g potatoes	9,0	218,9	70,4
510 g rice	7,0	72,9	18,2
355 g pasta	4,0	88,8	12,7

Table 50: Consumption of other products

Overig	Consumers	Average consumption per consumer (g)	Average consumption per respondent (g)
550 g plant based dairy	4,0	137,5	19,6
350 g frozen meals	1,0	350,0	12,5
122 g sauces	7,0	17,4	4,4

APPENDIX D: QUESTIONS INTERVIEW

Dr. R.J.K. Helmes (Dutch)

Algemene vragen

1. Waar houdt u zich zoal mee bezig?

Inhoudelijk algemeen

2. Hoe wordt normaal gesproken de duurzaamheidsbeoordeling van landbouwproducten gedaan?
3. Wat betekent life cycle assessment in onderzoek?
4. Hoe is het LCA perspectief anders dan de normale beoordelingsmethoden van landbouwproducten?
5. Hoe gaat u om met missende data voor duurzaamheid beoordelingen?
6. We lazen dat u bezig bent met het verbeteren van milieu impact beoordelingen met life cycle thinking, hoe werkt dit?
7. Wat houdt duurzaamheidsmonitoring voor retailers en foodservice in?

CO2-eq emissies vergelijken

8. In hoeverre kunnen producten in CO2-eq emissies met elkaar vergeleken worden?
9. Wat zijn belangrijke factoren in het bepalen van CO2-eq emissies van groente en fruit?
10. Waar kan je terug vinden op wat voor manier groente of fruit is verbouwd?
11. Wat zijn de vuistregels met betrekking tot het vaststellen van de CO2-eq van groente en fruit?
12. Wat zijn volgens u de grootste moeilijkheden/barrières in het onderzoeken naar GHG emissions?

Voorbeeld Mozzarella

13. We lazen dat u de duurzaamheid van mozzarella beoordeeld heeft, kunt u uitleggen hoe u dit gedaan heeft?

Inspireren bedrijven en overheden

14. U zegt dat u bedrijven en overheden inspireert met feiten over het milieu, het doel van onze commissioner is om duurzame gedragsverandering teweeg te brengen bij milieubewuste consumenten. Wat zijn uw ervaringen hier mee? *(Linkedin: For this purpose, I inform and inspire businesses and governments with facts from environmental assessments)*

Tot slot

15. Heeft u nog vragen en/of opmerkingen aan ons?
16. Wilt u het onderzoek later ontvangen per e-mail?

Dr. M.H. Vingerhoeds (Dutch)

Algemene vragen

1. Waar houdt u zich zoal mee bezig?

Theorieën en toepassingen

2. Welke theorieën denkt u dat interessant zijn voor gedragsverandering naar een meer duurzaam dieet?
3. Wat voor directe toepassingen (practices) zouden interessant kunnen zijn voor Prepit?
4. Hoe zou je het voor mensen makkelijker kunnen maken om over te stappen naar een duurzaam dieet?
5. Wat voor elementen zijn essentieel om gedragsverandering te bewerkstelligen?

Belemmeringen consumenten

6. Wat kunnen belemmeringen zijn voor mensen die een duurzaam dieet willen maar het niet doen? (intention-behavior)
7. Wat voor rol heeft social media hierin?

Communicatie

8. Hoe communiceer je informatie over duurzaamheid naar mensen?
9. Hoe zorg je ervoor dat mensen gemotiveerd raken om met duurzaamheid bezig te zijn?

Overige vragen

10. Heeft u nog tips of tricks voor het verdere onderzoek?
11. Heeft u nog bronnen die we zouden kunnen gebruiken?
12. Heeft u nog vragen en/of opmerkingen aan ons?

13. Wilt u het onderzoek later ontvangen per e-mail?

Dr.ir. J. Broeze (Dutch)

ACGE calculator

1. Kan u aanraden dat we voor het uitzoeken van de GHG emissions van groente en fruit de ACGE calculator gebruiken?
2. Waar haalt u de specifiek in te vullen data van de producten vandaan?
3. Heeft u hier een vaste methode/bronnen voor?
4. Stel we maken gebruik van de calculator, welke uitdagingen/barrières kunnen we verwachten in het gebruik?
5. Wat te doen bij missende data?
6. Hoe lang duurt het gemiddeld per product om in te voeren in de ACGE calculator?

Berekeningen RIVM

7. We proberen te achterhalen hoe de RIVM zijn berekeningen heeft gemaakt maar ze geven enkel aan gebruik gemaakt te hebben van ISO 140440/44 richtlijnen en de sima pro (servey) software. Ben je bekend met deze twee tools? Zo ja, wat is uw opinie over deze twee tools?
8. Wat is het verschil tussen uw calculator en de methode die gebruikt is door RIVM / Blonk consultancy?
9. Heeft u enig idee hoe RIVM/Blonk consultance aan zijn getallen gekomen is?

Overige vragen

10. Wat zijn alternatieven voor een inschatting van de GHG emissions?
11. Is er een lijst beschikbaar met ingevoerde voedselproducten met hun bijbehorende CO2-eq emissies?
12. Als de CO2-eq van een voedselproduct 'relatief' laag blijkt te zijn, kunnen we dan concluderen dat een product duurzaam is?

Tot slot

12. Heeft u nog vragen en/of opmerkingen aan ons?

dr. W. Verkerke (Dutch) en ir. E.H. Poot (Dutch)

Intro

1. Zou u ons kort kunnen vertellen wat glastuinbouw precies inhoudt?
2. Wat zijn de voor- en nadelen van glastuinbouw ten opzichte van teelt in de volle grond?
    - Is de opbrengst per m2 in glastuinbouw hoger dan in de volle grond? (plagen, ziektes?)

Duurzame kassen

3. U bent bezig met het verduurzamen van de tuinbouw industrie, hoe gaat u hierin te werk?
    - Welke belangrijke onderdelen komen hierbij kijken (CO2eq, water, bestrijdingsmiddelen)?
4. Als we het hebben over duurzame kassen, wat definiëren jullie dan als duurzaam?
5. Wat voor invloed heeft glastuinbouw op de natuurlijke omgeving en biodiversiteit?
6. Is het realistisch/rendabel om alle kassen in Nederlands volgens jullie standaarden te verduurzamen?

Food & glastuinbouw

7. Hoe is het te achterhalen of groente of fruit uit de volle grond komt of uit een verwarmde kas?
8. Voor welke groente en fruitsoorten is teelt in de volle grond duurzamer dan glastuinbouw? En andersom?
9. Ik las op de website het een en ander over het verbouwen van 'exotische' gewassen in Nederlandse kassen. Is het niet beter als we gewoon accepteren dat we geen exotische gewassen moeten eten?

APPENDIX E: INTERVIEW RESULTS

Organization	Wageningen Economic Research
Work field	Performance and Impact Agrosectors
Name Interviewee	Roel Helmes
Function	Researcher & Sustainability Measurer
Date Interview	04-06-2020

Main findings:

- Life Cycle Assessment is the golden standard, a quantitative method which is helpful in structuring available and unavailable information
- It is hard to include all details in calculating the CO2-eq emissions of food products. Because calculations are based on estimates (certain bandwidths), it is hard to compare two similar products. It is for example not relevant to compare two different types of yoghurt. However, it is interesting to make a comparison between a dairy product and a dairy substitute.
- In comparisons between food products, it remains difficult to include nutrient compositions.
- The difference in meat and vegetables is more relevant than differences between similar alternative food products.
- Rules of thumb:
    - Open ground versus horticulture, whereby open ground is way lower in its CO-eq emissions. However, this is not captured in food products. The best estimate can be made by use of the seasonal calendar.
    - Mode of transport. Also this rule of thumb is not captured. Estimates are based on country of origin.
    - Open ground or substrate. However, this difference in sustainability is difficult.

Organization	Wageningen Food & Biobased Research
Work field	FFC Food, Health & Consumer Research
Name Interviewee	Monique Vingerhoeds
Functie	Project Leader & Researcher
Date Interview	08-06-2020

Main findings:

- For meat substitutes, it is crucial to make it very tasty. If consumers try once a meat substitute and they do not like it, they are likely to buy meat again the next time.
- The way in which meat substitutes are promoted are associated with a certain type of consumers. For instance, vegetarians often disagree on naming a meat substitute after an existing meat product. They, in general, prefer other names for it instead of linking it to meat. How you should approach someone differs for each target group.
- Barriers for consumers to switch to a more sustainable diet can be:
    - The perception that it is harder to prepare a sustainable meal
    - Perceived price
    - Perceived taste
    - Status/image of a sustainable diet
- Older people are less motivated to change their diet, the focus should be on younger people. They are more motivated to make switches in their diet.
- Social media is a tensive medium. On social media it is important to not be too pedantic. If the message is too negative, people will feel too attacked and not examine the wanted behaviour.

Organization	Wageningen Food & Biobased Research
Work field	FFC Supply Chain & Information Management
Name Interviewee	Jan Broeze
Function	DLO Researcher
Date Interview	10-06-2020

Main findings:

- The Agro Chain Greenhouse gases Emissions (ACGE) calculator is intended for rough estimates. It works for instance with numbers of fresh vegetables from Europe, and not with numbers that are specific for a certain fruit or vegetable. However, if the kg CO2eq per kg harvested crop is known for a specific fruit or vegetable, this can be filled in manually. Also, the calculator does not distinguish in cultivation method yet.
- The crop CO2-eq emission factor is quite dominant in the calculation, but also losses, energy use, etc. are included in the calculation.
- The tool is not useful to compare diverse food categories.
- ISO standards are associated with certain agreements that scientists must comply. This is not something that should be taken into account in this project.
- Sustainability is a broad concept. There are various sustainability criteria. CO2 is essential because it is a threat to our society, but there are also other factors that are important when talking about sustainability. Examples of these other factors are animal welfare, transport, nitrogen emissions, and nuisance. Because sustainability is such a complex concept, it is hard to label something as sustainable. For instance, soya is a good meat substitute, but the cultivation of soya also contributes to deforestation. Also, soya is often associated with GMO. So the question is if soya can actually result in a reduction of CO2-eq emissions. Is eating soya truly a more sustainable alternative?

Organization	Wageningen Plant Research
Work field	Greenhouse horticulture & Business economics
Name Interviewee	Eric Poot
Function	Teamleader 'cultivation and quality'
Date Interview	19-06-2020

Main findings:

- Cultivating crops in greenhouses has the following advantages: less dependence on seasonality, climate change resistant, efficient use of fertilizers and water, higher yield per m2
- Greenhouse cultivation also has some significant disadvantages of which the most important is the high use of energy resulting in a high CO2-eq output. Besides this, the financial investment in greenhouse cultivation is considerably higher than cultivation in open ground.
- Currently the energy use of greenhouse cultivation makes an unsustainable practice. Therefore it could be argued that, generally speaking, cultivation in open ground is more sustainable. This is also the case for imported fruits and vegetables from, for example Southern-Europe, as long as these are transported by truck or ship. The CO2-eq output from greenhouse cultivation is higher than the emissions from transport. However, when looking at sustainability in terms of water-use, it could be argued that the cultivation in Dutch greenhouses is more sustainable when comparing the cultivation of crops in water-scarce areas.
- Many efforts are being made to make greenhouse cultivation more sustainable. The main focus here is on reducing the CO2-eq output and making use of renewable energies. Besides this, current innovations are focusing on recycling water in order to reduce water-use, but this will also prevent eutrofiering from occurring.
- It is very difficult for consumers to find out whether their fruits or vegetables were grown on open ground or in greenhouses. Generally the following fruits and vegetables are grown all-year

long in greenhouses: cucumbers, bell peppers, tomatoes, eggplant, radich and lettuce. Cultivation in the open ground are common for cabbages such as cauliflowers, broccoli and leek are grown in open ground.

- An increasing number of tropical fruits are (attempted) to be grown in greenhouses. It is argued that the quality of these products are higher when compared to importing products which have travelled several weeks. The cultivation of these tropical fruits in Dutch greenhouses are less sustainable however.

Organization	Wageningen Plant Research
Working field	Greenhouse horticulture & Business economics
Name Interviewer	Wouter Verkerke
Functie	Researcher 'cultivation and quality' and business developer 'kas als apotheek'
Date Interview	18-06-2020

Main findings:

- On the first of July, the PEF (Product Environmental Footprint) calculator will be published. The big advantage of such a calculator is that it makes products comparable out of the same product category. This calculator makes use of eight dimensions of sustainability, which can be assessed separately to determine
- the sustainability of a (food) product. These are the following dimensions:
    - Acidification
    - Global warming
    - Eutrophication
    - Photochemical potential
    - Abiotic potential
    - CO2
    - Water consumption
    - Land use

- Greenhouse horticulture makes protected cultivation possible. The biggest advantage of greenhouse horticulture is the controllability, increasing the yield per m2 significantly and decreasing the land use. The biggest disadvantage is the energy use. However, this will diminish over the years, due to technological developments. Another important disadvantage is light pollution.
- It is not possible to find out whether fruit or vegetables come from open ground or from a heated greenhouse. Eating locally produced foods will help to reduce the CO2-eq emission.
- The project 'kas als apotheek' aims to create new revenue models for growers in the Netherlands. The goal is to increase the farmer's income. However, the precondition for this is to increase sustainability.

APPENDIX F: METHODE

In order to answer the main question of this project 'What knowledge is needed for Prepit to contribute to reducing the CO2-eq emissions of the Dutch diet?', multiple activities were performed. The main research question was answered by taking the outcomes of all sub questions into account. The research methods for each sub question are described below.

For the first sub question, *'What choices in fruits and vegetables can consumers make in order to contribute to a more sustainable diet?',* the Dutch National Food Consumption Survey (DNFCS), conducted from 2012-2016 by RIVM, was used to get a reliable overview of the diet consumed by the Dutch population. Additionally, a survey was conducted amongst the Prepit community. This way, it was investigated which food products are commonly consumed by this group. Comparisons between the conducted surveys and the data of the DNFCS 2012-2016 are interesting for Prepit to target a broader population in the future. Also, these comparisons may be useful in proposing more appropriate advice towards the Prepit community. In addition, data collected among the Prepit community can provide insightful information about their dietary pattern. However, the data collected by the DNFCS 2012-2016 is more reliable and provides an overview of the average Dutch dietary pattern.

To gain more insights into the average CO2-eq emissions of fruits and vegetables, additional literature research was performed. In order to find useful literature, the snowball-method and citation-method were applied, to make sure all relevant information is collected (Hogeschool Rotterdam, n.d.). The snowball-method signifies using reference lists of papers to find more relevant literature (Wohlin, 2014). The citation-method is another method, whereby literature is found by using citation indexes for certain papers (Hogeschool Rotterdam, n.d.). It is expected that literature found through the databases Scopus, PubMed and Web of Science, can be considered reliable and valid information to answer the sub questions. Examples of search terms used for the literature research are: "CO2 emissions" OR "carbon footprint" OR "greenhouse gases" OR "ecological footprint" AND "fruit*" AND "vegetable*".

Furthermore, interviews were conducted with experts of Wageningen University and Research that are specialized in CO2-eq emissions of food, and in particular experts that are specialized in the field of cultivation and greenhouse horticulture. In this manner, knowledge was retrieved in order to know how to determine the average CO2-eq emissions of food products and what sustainable alternatives are. One of the experts that was interviewed for this study is Roel Helmes, who is a researcher in sustainability metrics. He works in the field of Performance and Impact Agrosectors and is an experienced user of Life Cycle Assessment (LCA). Furthermore, DLO Researcher Jan Broeze was interviewed, who works in the field of Fresh Food & Chains (FFC) Supply Chain & Information Management. Also, an expert that is employed in Greenhouse Horticulture & Business economics was interviewed. This expert is Eric Poot, who is a team leader of 'cultivation and quality'. Lastly, Wouter Verkerke was interviewed on this topic. He is a researcher in 'cultivation and quality' and business developer of 'kas als apotheek', working in the field of Greenhouse horticulture & Business economics. Furthermore, knowledge was retrieved to obtain more insights into the complex role of cultivation and greenhouse horticulture in relation to sustainable production. Questions were set up in advance, based on found literature and certain knowledge gaps found when searching for literature. Important and relevant findings of the interview were used for answering the subquestion. Besides, RIVM was contacted to gain insight into more specific data of the DNFCS 2012-2016 and to ask for advice on providing hard data on CO2-eq emissions. The factors taken into account when estimating the average CO2-eq emissions are described.

To provide an answer to sub question 2, '*What is needed in order to achieve behaviour change towards a more sustainable diet among Dutch consumers?',* literature research was performed to find existing theories and practices on behaviour change. Besides, the barriers for adapting a sustainable diet were investigated by conducting literature research as well. For this sub question, several search terms were used. Examples of these search terms are: 'behaviour change' AND 'diet' OR 'food products' OR 'consumers', 'theory of planned behaviour' OR 'intention-behaviour gap' AND 'sustainability'. Furthermore, literature research was performed on communication strategies in order to achieve behaviour change towards a more sustainable diet. For sub question 2, an interview was conducted with expert Monique Vingerhoed on behaviour change. She is a project leader and researcher, and works in the field of FFC Food, Health & Consumer Research. Lastly, several

concrete advices and examples of posts were provided for Prepit.

To answer sub question 3, '*To what extent does CO2-eq emission reduction of food contribute to combating climate change?',* literature research was needed to map the complexity of the issue of sustainable diets beyond looking only at CO2-eq emissions. Information was collected on the different factors that are of importance for analyzing environmental and social impact of food products. In order to gather this information the following search terms were used: 'supply chain analysis' OR 'cradle to retail' AND 'climate change', 'global trade map', 'food system approach', 'agricultural research for development', 'global food system', 'technocratic solutions' AND 'sustainability', 'transformative solutions' AND 'sustainability'. This literature research has been conducted according to the standards of the citation-methods and snowball-method. Lastly, food passports were created for fruits and vegetables to show the level of sustainability of three individual food products.

APPENDIX G: OUR TEAM

DORE DE JONG
Master Communication, Health and Life Sciences
Function: Member

- Bachelor: Health & Society at WUR
- Specialization: Health & Society
- Interest in Consumption and Healthy Lifestyle
- Positive & Practical

ACT - PREPIT

DORIS GROEN
Master Nutrition & Health
Function: Member

- Bachelor: Health Sciences at VU Amsterdam
- Specialization: Nutritional Physiology and Health Status
- Interest in Healthy & Sustainable diets
- Outgoing & inquisitive resource investigator

ACT - PREPIT

NAOMIE TIEKS
Master International Development Studies
Function: Controller

- Bachelor: International Development Studies at WUR
- Specialization: Sociology of Development
- Interest in alternatives to Development and Sustainability
- Creative & Critical

ACT - PREPIT

PAULA VAN EERDE
Master Communication, Health and Life Sciences
Function: Secretary

- Bachelor: Health & Society at WUR
- Specialization: Health & Society
- Affected by health & climate change
- Flexible team-worker

ACT - PREPIT

SOPHIE TERHAARD
Master Nutrition & Health
Function: Member

- Bachelor: Nutrition & Health at WUR
- Specialization: Nutritional Physiology and Health Status
- Special interest in global food security and how we can achieve this in a sustainable way
- Hard working

ACT - PREPIT

ZOË VAN DER HEIJDEN
Master Nutrition & Health
Function: Member

- Bachelor: Nutrition & Health at WUR
- Specialization: Nutritional Physiology & Health Status
- Nutritionist with a great interest in sustainability
- Enthusiastic team-worker

ACT - PREPIT

SIFRA EIGENRAAM
Master Nutrition & Health
Function: Manager

- Bachelor: Nutrition & Health at WUR
- Specialization: Nutritional Physiology and Health Status
- Interest in Communication Sciences
- Enthusiastic and committed

ACT - PREPIT