A healthy protein transition

To: the Minister of Agriculture, Nature and Food Quality and
the State Secretary for Health, Welfare and Sport
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Health Council of the Netherlands

contents

Executive summary 4

01 Introduction 8

1.1 Introduction and request for advice 9
1.2 Committee and methodology 11
1.3 Scope 13
1.4 Reading guide 14

02 The protein transition 15

2.1 Proteins and protein sources 16
2.2 Specifics of the protein transition 18
2.3 Protein quality 19
2.4 Dietary reference values and bioavailability 20

03 The protein transition and the health of the general population 22

3.1 Approach 23
3.2 Empirical research into plant-based diets 23
3.3 Modelling studies into plant-based dietary patterns 26
3.4 The protein transition and nutrient supply 27
3.5 Substitution and optimisation studies both point in the same direction 35
3.6 Summary and conclusions 36

04 The protein transition for specific groups 38

4.1 Specific groups of the general population 39
4.2 People with chronic diseases or obesity 39
4.3 Children from the age of one 40
4.4 Pregnant and breastfeeding women 42
4.5 Older adults 44
4.6 People with low protein and energy intakes 46
4.7 Summary and conclusions 47

05 The vegetarian diet 49

5.1 The vegetarian diet and health 50

06 The environmental impact of the protein transition 54

6.1 Scientific developments 55
6.2 Environmental impact 59

07 Policy perspectives 67

7.1 A comprehensive approach 68

7.2 The food system transition 72

08 Advice 73

8.1 Answers to the request for advice 74

8.2 Recommendations on the protein transition 75

8.3 Future dietary guidelines 75

References 77

executive summary

Introduction and request for advice

The current levels of consumption and production of food exert significant pressure on the environment. Globally, the food system is estimated to account for approximately 30% of total greenhouse gas emissions, 60% of biodiversity loss on land and over 50% of nitrogen emissions. Research has shown that altering the food system is essential to meet climate targets and ensure a sufficient supply of healthy food for the global population in the future. A significant part of the Dutch diet's environmental impact comes from animal-based foods. Additionally, the consumption of certain animal protein sources is linked to an increased risk of chronic diseases. Moreover, our current diet is one of overconsumption: we are eating more than necessary.

Proteins are integral to a healthy diet. In the Dutch diet, proteins are primarily derived from meat (and meat products), dairy, bread, grains, rice and pasta. Currently, the majority (57%) of proteins come from animal-based foods. The Dutch government is aiming for a shift to a diet with more plant-based and fewer animal-based proteins, known as the protein transition. The goal is a 50% animal-based and 50% plant-based protein ratio by 2030, according to the Wheel of Five. Calculations indicate that a further shift to plant-based proteins is needed to reduce environmental impact. At the request of the Minister of Agriculture, Nature and Food Quality and the State Secretary for Health, Welfare and Sport, the Health Council of the Netherlands has examined the health consequences of the protein transition, particularly the shift to a diet with 60% plant-based and 40% animal-based proteins. The Health Council was also asked to assess the environmental impact of this shift and its implications for future dietary guidelines.

Committee and methodology

This advisory report was prepared by the Health Council's temporary Protein Transition Committee. The advisory report is based on empirical research into the relationship between a more plant-based diet, protein sources and chronic diseases or its risk factors. The committee also assessed the nutritional effect of a shift toa more plant-based and less animal-based diet through modelling research, focusing on both the general population and specific groups. Additionally, the committee assessed the effect of the protein transition on the environment.

The protein transition as a shift and decrease

The protein transition involves a change in the diet of a large part of the Dutch population. This change goes beyond proteins, as the protein

transition also affects the intake of other nutrients. In this advisory report, the committee uses the term ‘protein transition’ for the shift to a diet that includes more plant-based and fewer animal-based proteins without sacrificing energy intake. The committee specifically focused on the shift to60% plant-based and 40% animal-based proteins. In practice, this will also result in a decrease of total protein intake, as plant-based protein sources generally contain fewer proteins than animal-based sources.

The protein transition will improve the health of the general population

The committee has concluded that the shift to a diet with 60% plant-based and 40% animal-based proteins is beneficial for the health of most Dutch people. This diet aligns better with the Dutch dietary guidelines than the current Dutch diet. An important advantage of the protein transition is that it will reduce the risk of chronic diseases. A healthy (more) plant-based diet with whole grains, fruits, vegetables, nuts and legumes lowers the risk of cardiovascular disease, type 2 diabetes and cancer.

Reducing the consumption of red and processed meats is also associated with a lower risk of disease. Furthermore, the protein transition will lead to a decrease in the intake of saturated fats and possibly salt, while increasing the dietary fibre intake. The committee expects no detriment to muscle and bone health for the general population due to the protein transition.

The committee investigated whether the protein transition could result in deficiencies in certain nutrients. Animal-based foods are a source of not only protein, but other nutrients as well. The committee has concluded that it is possible to implement the protein transition without causing nutrient deficiencies. Regarding animal protein sources, the committee recommends reducing meat consumption and not consuming more fish and dairy than advised. To increase the intake of plant-based protein sources, the committee advises consuming more legumes and nuts and to vary with protein sources. For meat, dairy and fish alternatives, it is essential that their nutritional composition improves, since these products often contain excessive added salt or sugar. For the benefit of consumers who regularly use these alternatives, the committee emphasises the importance of ensuring that such products provide essential nutrients in quantities comparable to the products they replace.

Since the current Dutch diet already provides more than enough protein, a decrease in total protein intake would not result in a deficiency for most Dutch people. The committee advises to keep monitoring the intake of vitamins A, B2 and B12, calcium, iron (in girls and women of childbearing age), iodine and fish fatty acids.

The protein transition for specific groups

The committee explored how the protein transition will affect specific groups of the general population, including people with chronic diseases

or overweight, children, the elderly, pregnant and lactating women, and people with low protein and energy intakes. For some groups, meeting dietary reference values may be more challenging due to higher dietary reference values or lower food intake. Limited data on food consumption and nutritional status for these groups make it challenging to estimate the consequences. However, based on the available information, the committee sees no reason to believe that the effects of the protein transition would differ for these groups. Pregnant women, breastfeeding women and those with low protein and energy intakes (e.g. due to illness or vulnerable health) require more attention. If they choose to shift to a more plant-based diet, they should do so with well-informed, for example with help from a dietitian.

A vegetarian diet as a way to realise the protein transition

The committee suggests that adopting a vegetarian diet with fish included once a week is one way to achieve the 60% plant-based and 40% animal-based protein ratio. However, attention is needed for vegetarian diets of children, pregnant and breastfeeding women, and those with low protein and energy intakes.

In 2001, the Health Council recommended a higher protein intake for vegetarians and vegans to compensate for the potentially lower protein quality in their diet. Based on new calculations, the committee has concluded that this higher protein recommendation for vegetarians is no longer necessary. The protein recommendation for vegetarians is now in line with that for the general population. The recommendation for vegans remains unchanged, as there is insufficient data to revise the existing recommendation.

The protein transition will reduce the environmental impact

It is estimated that the shift toa diet with 60% plant-based and 40% animal-based proteins could lead to a reduction of approximately 25% of the environmental impact compared to the current diet. This reduction applies to both greenhouse gas emissions and land use.

The environmental impact could be reduced further by making different choices within product groups. For example, white meat (such as chicken) has a lower environmental impact than red meat (such as beef).

The committee notes that achieving environmental targets will require more than the protein transition. It will also be necessary to avoid overconsumption, to combat food waste and to reduce the environmental impact via innovation in production systems.

Recommendations

The committee views the protein transition as a dietary change that will benefit the health of most Dutch people and yield environmental gains. Therefore, it recommends implementing policy measures targeting the entire population to achieve the current policy goals (a 50:50 ratio) and subsequently progress toa further shift to 40%

animal and 60% plant-based proteins. Attention should be paid to pregnant women, breastfeeding women and those with low protein and energy intakes, enabling them to make informed dietary choices in making the shift. Information on nutrition should target both consumers and dietitians and caterers.

The committee further advises monitoring the progress and health effects of the protein transition through food consumption and nutritional status research in a more diverse range of population groups than currently considered. This should include consideration of different diets and food cultures. The committee recommends incorporating scientific data on environmental impact when quantifying future dietary guidelines and to inform recommendations on product choices within food groups.

Furthermore, the committee advises stimulating research into:

1. the bioavailability of nutrients in plant-based diets;
2. the health effects of meat, fish and dairy alternatives, as well as alternative (new) protein sources;
3. the environmental effects of animal, plant and alternative protein sources, with attention for transparency of data;
4. the potential environmental gains from avoiding overconsumption;
5. the effects of interventions (including policy measures) targeting the food environment and behaviour change.

Policy focused on a comprehensive approach

The intake of plant-based proteins in the Netherlands has generally increased in recent years, while that of animal-based proteins has decreased. However, a faster shift is necessary to achieve the policy goal of 50% plant-based and 50% animal-based protein by 2030 and to reduce the environmental impact of the Dutch diet further. Currently, food policy mainly emphasises the consumer's responsibility, but the committee finds this approach too limited. It recommends a robust policy that strives for a physical, social and economic environment where healthy and sustainable diets become the norm. Moreover, this transition can only occur if all parties involved in the food chain take responsibility.

01 introduction

1.1 Introduction and request for advice

The current levels of consumption and production of food exert significant pressure on the environment. Globally, the food system is estimated to account for approximately 30% of total greenhouse gas emissions, 60% of land biodiversity loss and over 50% of nitrogen emissions.[1-3] Altering the food system is essential to meet international sustainability goals and secure global food supply for future generations[4,5] (see the text boxes The food system and planetary boundaries and Policy goals to reduce environmental pressure on the next page). Animal-based products are significant contributors to the environmental impact of the food system for a number of reasons, including high greenhouse gas emissions and land use.[1,6,7] Overconsumption – including the overconsumption of proteins – is another known issue in our current diet. These are some of the factors that have put the protein transition on European and Dutch policy agendas. The protein transition is a shift in consumption from animal-based to plant-based proteins.[8,9]

Currently, the majority (57%) of proteins in our diet come from animal-based sources. Government policy states that 50% of proteins are to be derived from animal-based sources and 50% from plant-based sources by 2030.[10] This goal was prompted by the *Dutch dietary guidelines 2015*, in which a more plant-based and less animal-based diet is recommended (see the Dutch dietary guidelines text box), and the Wheel of Five based on these guidelines (with meat limited to a maximum of 500 grams per week). For environmental reasons, a further shift to 60% plant-based proteins is recommended.[8,11]

The starting point for government is for the protein transition to take place within the boundaries of a healthy dietary pattern.[8,9,12] For this reason, the Minister of Agriculture, Nature and Food Quality and the State Secretary for Health, Welfare and Sport have asked the Health Council of the Netherlands what the expected nutritional consequences would be of the protein transition for the general population and for physically vulnerable groups (like the elderly, children and people who are in poor health) in particular. The government has specifically asked the Health Council of the Netherlands to consider the nutritional consequences of a change from 60:40 to 40:60 in the ratio of animal-based to plant-based proteins in people's diets, whether or not in combination with a reduction in protein consumption. The government would also like the response of the Health Council of the Netherlands to include a general outline of the sustainability impact of the protein transition and an initial basis for an approach to the integration of health and sustainability that could be used for future dietary guidelines.

The food system and planetary boundaries

The food system consists of every actor and activity involved in the production, processing, distribution, preparation and consumption of food and also the outcomes of these activities, including social, economic and environmental outcomes.[13] Globally, the food system is estimated to account for approximately 30% of total greenhouse gas emissions, 60% of land biodiversity loss and over 50% of nitrogen emissions.[1-3] It also monopolises 35%-40% of land and 70% of the fresh water extracted is used to irrigate agricultural land.[1,2,14] Dutch food consumption is responsible for approximately 13% of Dutch greenhouse gas emissions as a whole. The percentage of food-related land use (both in the Netherlands and elsewhere) for the purpose of total Dutch consumption is approximately 38%.[1] The expectation is that demand for food and, as such, pressure on the environment will continue to increase: the global population is growing and increasing prosperity is prompting a relative increase in demand for animal-based products, sugar and fat.[6,15,16] The food system thereby contributes to exceeding the so-called 'planetary boundaries'.[17] Globally, a number of boundaries have already been exceeded.[18,19] This is jeopardising the stability of the climate, biodiversity and the nutrient cycle, amongst other things. Our food supply is under threat as a result, both now and for future generations.[6,20]

Policy goals to reduce environmental pressure

Policy goals for reducing environmental pressure have largely been formulated as part of European and Dutch agreements on the climate, the circular economy, nature and biodiversity.[12,21-24] For example, by 2030, the Netherlands aims to have reduced its greenhouse gas emissions by 55% compared with 1990.
The Netherlands also wants to be climate-neutral by 2050.[12] In 2022, the Netherlands committed itself to the goals of the Global Biodiversity Framework, which include reducing the footprint of consumption, bringing down over-consumption and halving food waste.[24] Lastly, the Netherlands wants to have become a fully circular economy by 2050.[21] Where food policy is concerned, the European Farm-to-Fork strategy applies; it aims to make the food system fair, healthy and environmentally friendly.[23] The strategy includes measures geared towards making diets healthier and reducing food waste and the use of pesticides.

An important part of the Farm-to-Fork strategy is a Code of Conduct for companies in the food chain. One aim is to make the food chain climate-neutral by 2050.[25] Dutch food policy focuses on goals that include reducing the green-house gas emissions generated by food production, promoting circular agriculture and more efficient use of food sources, combating food waste and making dietary changes.[8-10,26,27]

The Dutch dietary guidelines

The *Dutch dietary guidelines 2015* describe what a healthy diet is for the general population.[28] In these guidelines, the Health Council of the Netherlands describes the food and drink intake recommended in order to prevent the 10 main chronic diseases. These include cardiovascular disease, type 2 diabetes and several types of cancer in the general population aged two and over.[28,29]

Dutch dietary guidelines 2015:

- Follow a dietary pattern that involves eating more plant-based and less animal-based food, in accordance with the following guidelines
- Eat at least 200 grams of vegetables and at least 200 grams of fruit daily
- Eat at least 90 grams of brown bread, wholemeal bread or other wholegrain products daily
- Eat legumes weekly
- Eat at least 15 grams of unsalted nuts daily
- Take a few portions of dairy products daily, including milk or yoghurt
- Eat one serving of fish weekly, preferably oily fish
- Drink three cups of tea daily
- Replace refined cereal products with wholegrain products
- Replace butter, hard margarines and cooking fats with soft margarines, liquid cooking fats and vegetable oils
- Replace unfiltered coffee with filtered coffee
- Limit the consumption of red meat, particularly processed meat
- Minimise consumption of sugar-containing beverages
- Do not drink alcohol or limit alcohol consumption to one glass per day
- Limit salt intake to 6 grams daily
- Nutrient supplements are not needed, except for specific groups for which supplementation applies

1.2 Committee and methodology

This advisory report was prepared by the Health Council of the Netherlands' temporary Protein Transition Committee (hereinafter 'the committee'). The draft version of this advisory report was submitted to a panel of external experts for its input. See the end of this report for information about the composition of the committee and the expert panel.

The committee has been tasked with identifying the consequences of the shift to a diet with less animal-based and more plant-based proteins and, if possible, specifically the shift to a diet with 40% animal-based and 60% plant-based proteins. The committee focuses on the consequences of the protein transition for health, both with regard to the risk of chronic diseases and nutrient supply. Research into the vegetarian diet has been included in this advisory report as an example of a diet with 60% plant-based and 40% animal-based proteins. Research has likewise been included into the health effects of the vegan diet, because its provides an insight into the health effects of the most extreme shift to a plant-based diet (see the Diets text box on page 14).

The committee has used the following information sources to estimate the consequences of the protein transition for health and sustainability:

- Data about current intake (protein, protein quality, energy, and nutrients that are derived primarily from animal-based protein sources) and its sufficiency, both for the general population and various specific groups

in the general population (health);
- Empirical research in which the relationship is studied between consuming a more plant-based versus a less plant-based diet and protein sources, and (risk factors for) chronic diseases (health);
- Substitution studies: modelling studies that estimate the effect on nutrient intake when one or more foods are replaced (health and sustainability);
- Optimisation studies: modelling studies that provide an insight into which food groups or foods ought to be consumed more or less to meet health and sustainability conditions (health and sustainability).

Empirical research and the two types of modelling studies complement each other. Empirical research focuses on existing diets in the population. It reports on the effect that diets have on nutrient adequacy and on the health outcomes of people who are already consuming more plant-based and less animal-based (proteins) than other people. This can provide an insight into the consequences to be expected for the health of the Dutch population if more people were to shift to a more plant-based and less animal-based diet. Modelling studies focus on theoretical shifts in diets. This makes it possible to study bigger shifts than empirical research allows. Virtually no research was available that looked specifically at the shift from a diet with 40% plant-based protein to a diet with 60% plant-based protein. Therefore, the committee also conducted an optimisation study into the impact a shift of this nature would have on both health and the environment.

The committee used the information collected as the basis for conclusions about the expected effects of the protein transition on the health of the Dutch population and the environment.

Diets

Omnivorous diet
A diet that consists of both animal-based and plant-based products. This term is usually used to describe a diet that also includes meat and fish.

Plant-based diet
A diet that consists entirely, or almost entirely, of plant-based products. This term is defined in many different ways in scientific literature on the subject: fully plant-based (vegan) diets, all kinds of different types of meat-free diets[30] or diets based on the relative proportion of plant-based food. The different types of 'plant-based' diets are often lumped together in research. In this advisory report, we refer to a *more* plant-based diet to indicate a shift to *more* plant-based products *compared with* the current, often omnivorous diet.

Vegetarian diet
A diet that is completely meat-free (without any meat, poultry, fish or insects) and also free of gelatine and non-vegetarian rennet. Various definitions exist of the vegetarian diet: pescatarians do consume fish, pollotarians do consume poultry, ovo-vegetarians do not consume dairy but do consume eggs and lacto-vegetarians do not consume eggs but do consume dairy. A distinction between these groups is often absent in scientific literature and the term 'vegetarian' is often used as a blanket term for people who do not consume meat.
The committee uses the term 'vegetarian diet' to signify a meat-free diet that might include fish.

Vegan diet
A fully plant-based diet.

1.3 Scope

Where health effects are concerned, the committee will focus first on the general population, followed by a number of specific population groups. The committee has chosen not to include children up to the age of one in the scope of this advisory report; this group is covered in the advisory report 'Healthy nutrition: the first thousand days'.[31] It has also chosen not to focus specifically on athletes, or patient groups in which patients are on a diet in which protein intake plays a role (kidney patients, for example) or in which they are trying to regain muscle mass. These patients need specialist nutritional guidance. People who play sports recreationally fall under the general population.

The committee has been asked to outline what is known about the sustainability impact of the protein transition. Although the definition of a sustainable and healthy diet also includes accessibility, affordability, safety, fairness and cultural acceptability,[32,33] the committee focuses primarily on the environmental impact.

In the current advisory report, the committee includes a number of considerations about the integration of health and sustainability that can be used for future dietary guidelines.[31]

The committee does not look at alternative proteins in this advisory report, i.e. plant-based and animal-based proteins that are currently not being

consumed in the Netherlands, or just minimally. Examples include protein from insects, algae and cultured meat. The committee is of the view that too little is known about the (nutritional) composition of these proteins, their potential role in diets and their environmental impact if consumed on a large scale.

1.4 Reading guide

In Chapter 2, the committee describes what the protein transition will entail. It then uses empirical research and modelling to explain the expected consequences of the protein transition for the health of the general population (Chapter 3) and specific groups (Chapter 4).
In Chapter 5, the committee discusses nutritional aspects of the vegetarian diet, as an example of a diet with 60% plant-based and 40% animal-based proteins. The vegan diet is also briefly discussed here. The committee then turns its attention to the request for advice on the environmental impact of the protein transition and protein sources (Chapter 6). In Chapter 7, the committee identifies a number of policy perspectives for the protein transition. In Chapter 8, the committee formulates its advice and makes recommendations in respect of the protein transition and future dietary guidelines.

The advice of the committee is accompanied by seven background documents that report in more detail on the research used.

02 the protein transition

The protein transition involves a change in the diet of the majority of the Dutch population to a diet with 60% plant-based proteins. This change goes beyond proteins, as the protein transition also affects the intake of other nutrients. In this advisory report, the committee uses the term ‘protein transition’ for the shift to a diet that includes more plant-based and fewer animal-based proteins without a change in energy intake. The committee specifically focused on the shift to 60% plant-based and 40% animal-based proteins. In practice, this will also decrease the total protein intake, as plant-based protein sources generally contain fewer proteins than animal-based sources.

2.1 Proteins and protein sources

Proteins are integral to a healthy diet. In the Dutch diet, proteins are primarily derived from meat (and meat products), dairy, bread, grains, rice and pasta.[34] In the gastrointestinal tract, the proteins contained in food are broken down into amino acids. Once absorbed into the body, these amino acids are used to build body proteins. Proteins function as building blocks for the body (including muscles) and also fulfil specific functions, such as transporting substances within and between cells, enzyme activity, communication between cells and their environment and ensuring that the immune system works properly. Proteins also provide energy. Amino acids are classified as either ‘essential’ or ‘non-essential’. Essential amino acids cannot be synthesized by the body, so they have to be present in sufficient quantities in the diet.[29]

The majority of proteins in our diet come from animal based foods

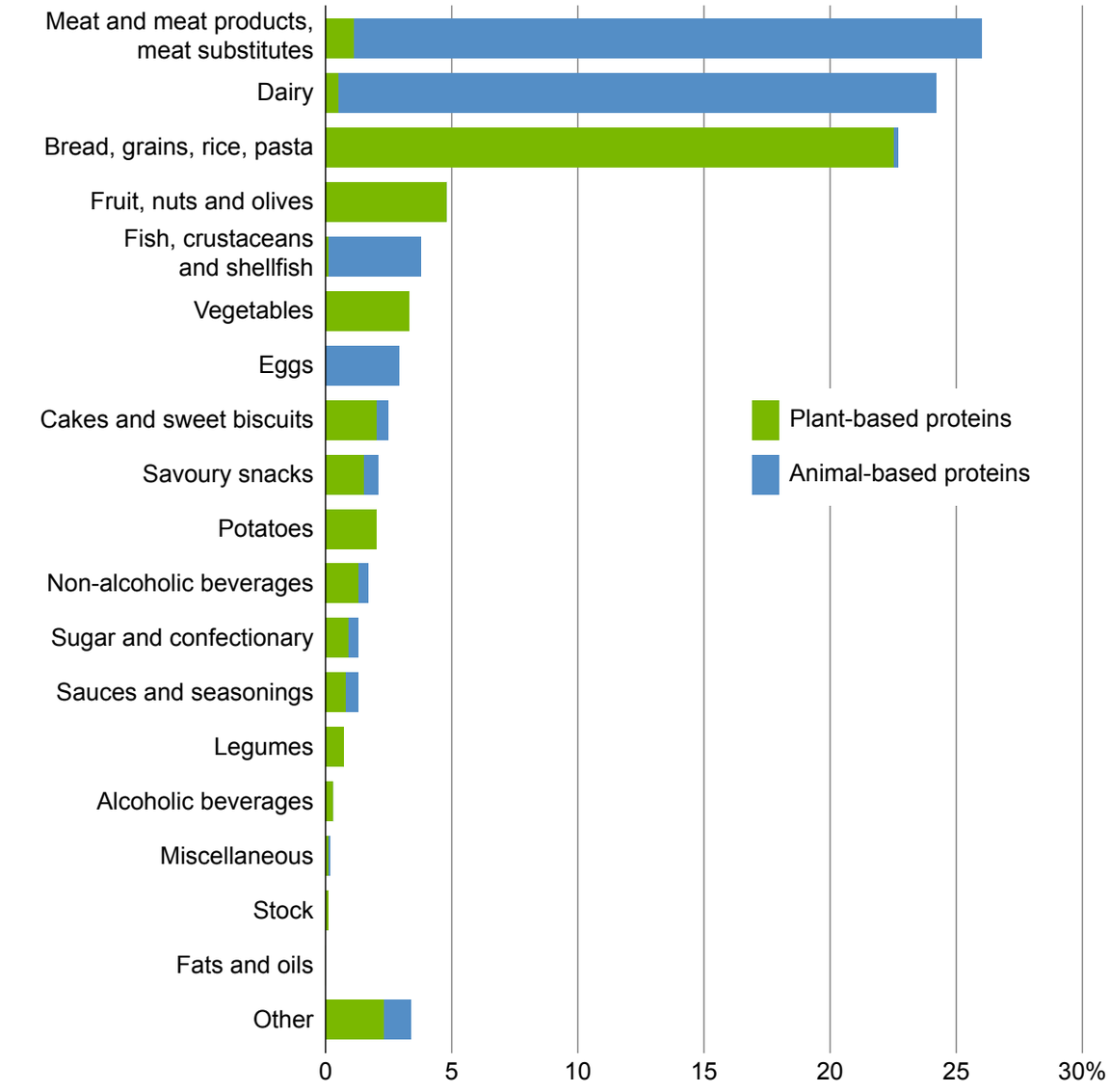


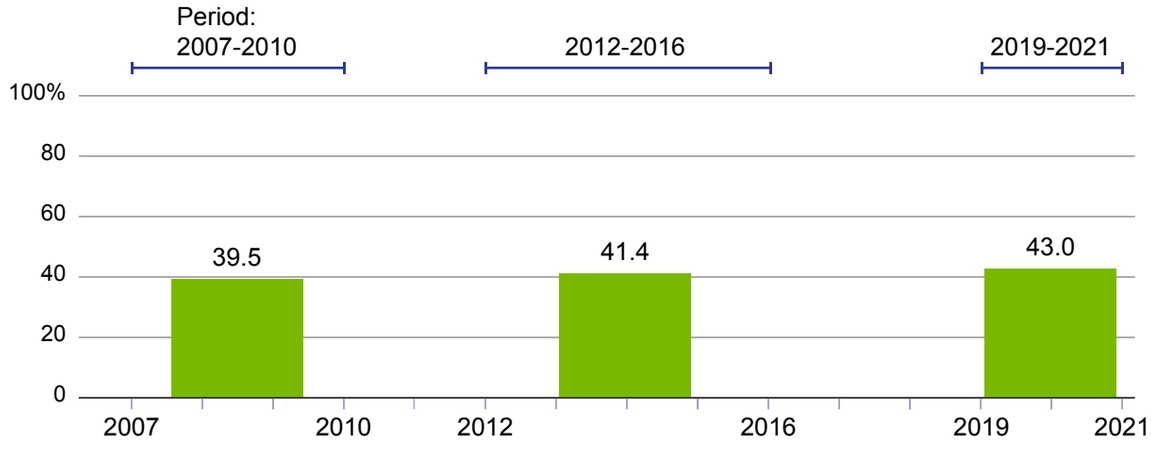
Figure 1 Ratio of plant-based to animal-based proteins in the diet[34]

The Dutch National Food Consumption Survey (DNFCS) 2019-2021 shows that the majority of proteins in our diet comes from animal-based

foods (see Figure 1).[34,35] The majority of animal-based protein comes from meat (~46%), followed by dairy (~42%), fish (~7%) and eggs (~5%). However, the average relative amount of plant-based protein intake compared to the total amount in a 12-year period has increased slightly from 39.5% to 43.0%. This is shown by data from three consecutive food consumption surveys between 2007-2010 and 2019-2021[34] (see Figure 2 and the Trends in food consumption in relation to the protein transition text box). The proportion of plant-based protein decreases with age (see Figure 3 on the next page).

The proportion of plant-based protein is slowly increasing

Plant-based protein as a percentage of total protein consumption among 7–69-year-olds, 2007–2021



The total protein intake is slowly decreasing

Average total protein intake (in grams per day) among 7–69-year-olds, 2007–2021

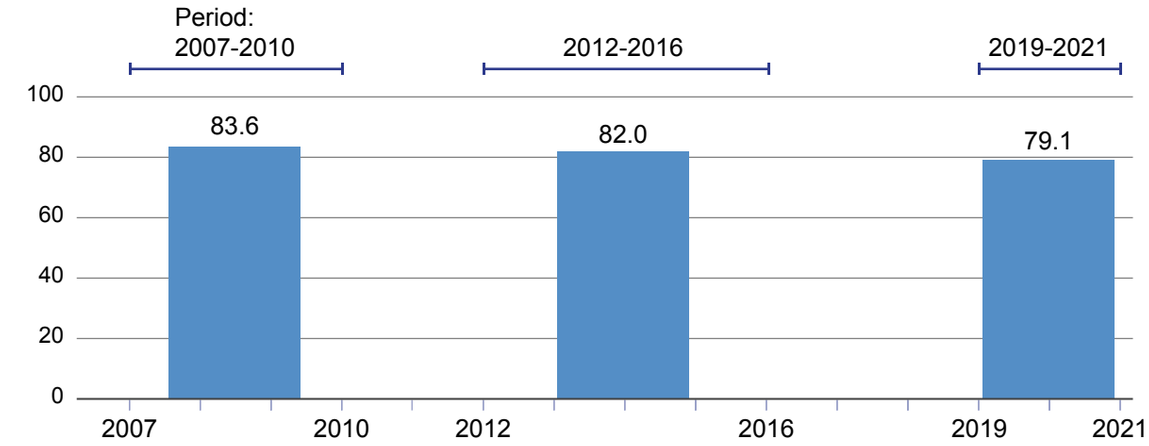


Figure 2 Shift in protein intake over the years[34]

The proportion of plant-based protein changes with age

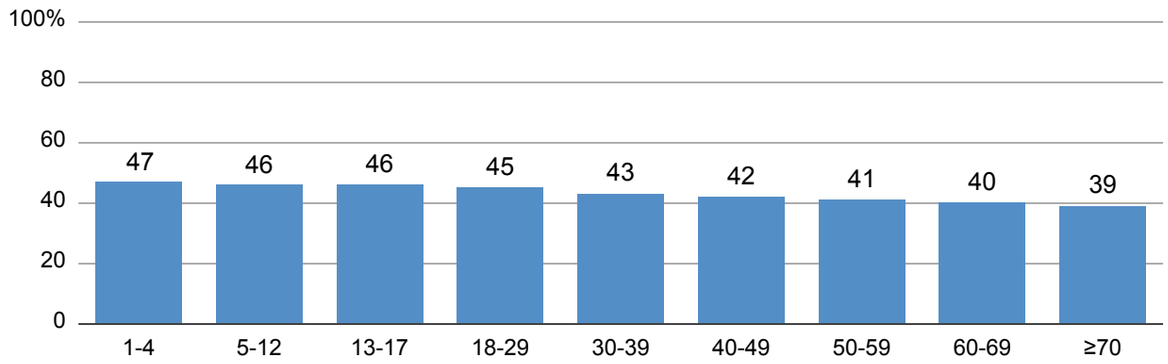


Figure 3 Plant-based protein as a percentage of total protein intake, by age[34]

Trends in food consumption in relation to the protein transition

The consumption of meat and dairy in the Netherlands has decreased over the years. For example, meat consumption in 2019-2021 decreased by 18% compared with 2007-2010 and dairy by 14%. The consumption of plant-based products like fruit, vegetables and legumes has increased, although legume consumption is still quite low (they are consumed two days a month on average). The consumption of meat substitutes has increased from an average of 1 gram to 5 grams per day.[35] The proportion of people who call themselves flexitarians has increased considerably, from 13% to 43% between 2011 and 2019.[36] However, the extent to which people are flexitarian has decreased. More flexitarians are consuming meat five to six times a week and fewer flexitarians are consuming meat a maximum of twice per week.[36]

2.2 Specifics of the protein transition

The protein transition involves a shift to a diet with 60% plant-based and 40% animal-based proteins at the general population level.

The committee assumes that as many population members as possible who have a diet with an animal-based protein proportion of more than 40% will move to a proportion of 40% animal-based protein (and 60% plant-based). As such, the protein transition will mean a change in diet for a big part of the Dutch population, in stead of a smaller group shifting to an extreme plant-based diet.

The protein transition will bring with it a change in the consumption of various food sources and, because of this, a change in the diet as a whole. The lower consumption of animal-based protein sources like meat, dairy and fish will affect the intake of nutrients that are found in these products, which could put the adequacy of these nutrients under (further) pressure. With the above in mind, the committee will focus not only on protein but also on fish fatty acids and the vitamins and minerals for which meat, dairy and fish are important sources in the Netherlands (being in the top three).[37] The increase in plant-based protein sources will also benefit the intake of various healthy nutrients like dietary fibre. Furthermore, plant-based protein sources generally contain fewer unhealthy nutrients like saturated fat and salt than animal-based protein sources do.[38]

Bread and ready-made meat and fish substitutes may contain relatively high levels of salt though, while dairy substitutes may contain relatively

high levels of sugar. In this advisory report, the committee considers both the favourable and unfavourable effects of more plant-based and less animal-based diet.

Plant-based protein sources generally contain less protein than animal-based protein sources do. In practice, this means that the shift to more plant-based protein food will reduce the total protein intake. To maintain the total level of protein, far more plant-based food would need to be consumed, which could also lead to an increase in the total energy intake.[39] Quite apart from the question of how feasible it would be to consume so much more plant-based food (due to its high satiety and the volumes involved), an increase in energy intake would be undesirable for most people. In this advisory report, therefore, the committee focuses on the consequences of a protein transition in which there will be a shift to more plant-based and less animal-based proteins and a decrease in the total protein intake, unless stated otherwise. The energy intake will remain approximately the same for such a shift.

2.3 Protein quality

It will be vital to maintain protein quality in people's diets during the protein transition. Protein quality is optimal if a diet provides all the important building blocks of protein (amino acids) in sufficient quantities (see the Protein quality text box on the next page). Individual protein sources, particularly plant-based ones, contain a relatively low percentage of some of the amino acids required. For example, grain products contain a relatively low level of lysine, while legumes contain relatively little methionine and cysteine, two sulfur-containing amino acids. If different protein sources are combined in a diet, they can supplement each other's limiting amino acids. In addition, any reduction in protein quality could be compensated by a higher protein intake.[40,41] If the total amount of protein decreases, the possibility for this compensation could be less.

Much is still unknown about the concept of protein quality, the absorption of proteins from various food sources and physiological effects (see the Protein quality text box). The committee discusses the possible consequences of the protein transition on protein quality in more detail in Chapters 4, 5 and 6.

Protein quality

International advisory bodies define the term ‘protein quality’ as the quantity of essential amino acids that become available to the body (after digestion) compared to the amino acids required when protein intake is at the recommended level. A measurement method that an FAO expert group has advised in this respect since 2013, in replacement of the Protein Digestibility-Corrected Amino Acid Score (PDCAAS), is the Digestible Indispensable Amino Acid Score (DIAAS) method.[41] However, a great deal of research had to be conducted before it would be possible to use the DIAAS. More and more of this new research is now becoming available. The expectation is that DIAAS data will become available for many foods in the next few years. At the moment, WHO reference patterns from 2007 are being used to determine the requirements for amino acids.[42] However, much is still unknown about how body proteins and specific amino acids work. As such, the reference patterns themselves are the subject of scientific discussion as well, as is the extent to which specific patterns should be assumed for such groups as the oldest seniors and pregnant women.[43]

For many years now, discussion has also been ongoing about the period of time within which protein sources need to be consumed together to supplement each other’s limiting amino acids.[44-46] If amino acids cannot be utilised on time, the body will use them as fuel (an energy source).[44] The discussion about timing becomes particularly relevant if the protein intake is (too) low. Furthermore, too few data are available as yet about the extent to which the human body is able to adapt to a lower protein intake.[42,47]

2.4 Dietary reference values and bioavailability

The committee has used the dietary reference values to assess the adequacy of nutrients in a more plant-based diet. These reference values provide information about the nutrient amounts healthy people with a healthy weight need to consume every day to avoid deficiency symptoms, keep the body functioning properly and minimise the risk of chronic diseases (see the Dietary reference values text box on the next page).[29,48-50] Like the *Dutch dietary guidelines*, the dietary reference values for the Netherlands are derived by the Health Council of the Netherlands.[51] It is important to observe here that the intake of a nutrient below the dietary reference value does not automatically result in a deficiency; this is because the recommended amounts are higher than the amounts most people actually need.

The bioavailability of some nutrients – in other words, the extent to which they are absorbed by the body – is higher on average in animal-based foods than in plant-based products. This applies particularly to protein[52,53] and to iron and zinc.[54,55] Bioavailability is also influenced by the preparation method used and by other foods or nutrients that are consumed at the same time. Phytate is a nutrient that is found in plant-based foods, especially grains and legumes. It inhibits the absorption of zinc, iron and protein, because of which it is referred to as an anti-nutritional factor. When establishing dietary reference values, the bioavailability of nutrients is estimated based on the diet of the population

in question. If the proportion of plant-based foods in a diet increases, this could mean that the bioavailability assumed when establishing the reference values no longer applies. However, research based on 32 studies showed no difference in the estimated protein requirement on the basis of proteins from animal-based or plant-based foods.[56] Where iron is concerned, the European Food Safety Organisation (EFSA) concluded in 2015 that no adjusted values were necessary for people in Europe with a vegetarian diet, because the (total) bioavailability of iron in vegetarian diets would not differ substantially from diets containing meat.[57] It is more difficult to estimate the effect of changes in bioavailability for zinc. Although phytate plays a role here, the Health Council of the Netherlands felt that the EFSA had put too much emphasis on this role when setting dietary reference values for zinc.[58,59] Moreover, no data are available on phytate intake in the Netherlands.

Also regarding to shift to a more plant-based diet, the committee proceeds on the basis of the current dietary reference values. Its reasoning is that changes in bioavailability will be relatively limited in a Western diet with 60% plant-based protein. However, the committee does feel it is important for more research to be conducted into variation in the bioavailability of proteins, vitamins and minerals based on (bigger) shifts, and for adequacy to be monitored for population groups with different diets.

Dietary reference values

There are various dietary reference values. The average requirement is the intake level that would meet the individual requirement of half of the population but not the other half of the population. The average requirement is used to estimate whether the intake of a population is adequate. The individual requirement is not known, which is why also dietary reference values are derived that are considered sufficient for almost all individuals in the population: the population reference intake or adequate intake). The nutritional recommendations in the Wheel of Five have been drawn up to ensure that the intake of nutrients is adequate for (virtually) everyone (based on population reference intakes or adequate intakes) and also aligns with the *Dutch dietary guidelines*. Poorly supported reference values should not be used when providing information about nutrition or to assess the intake of a population.[49] If intake data are used to identify individuals or groups who are at risk of an intake that is too low or too high, confirmation will be necessary based on research into nutritional status (blood values, for example) or the occurrence of clinical symptoms.

So called tolerable upper intake levels' have been derived for a number of vitamins and minerals (vitamins A, B3, B6, D and E and synthetic folic acid, copper, iodine, magnesium, selenium and zinc). These limits apply if there are sufficient indications that a (chronically) high intake could have unfavourable consequences. Exceeding the upper intake levels is almost always a consequence of consuming too many supplements, supplements with an excessive dosage or an excessive amount of fortified foods. The upper intake levels for vitamins and minerals are rarely exceeded through the consumption of non-fortified foods alone. Exceptions to this non-fortified foods rule are liver (vitamin A), Brazil nuts (selenium) and seaweed (iodine).

03
the protein transition and the health of the general population

A shift to 60% plant-based and 40% animal-based protein will mean that the general population will consume a healthier diet that aligns better with the *Dutch dietary guidelines 2015*. As a result of the higher consumption of healthy, (more) plant-based foods like whole grains, fruit, vegetables, nuts and legumes and the lower consumption of red and processed meat, the risk of chronic diseases will decrease. The dietary shift will lead to a higher intake of dietary fibre and a lower intake of saturated fat and possibly salt. The committee expects no detriment to muscle and bone health for the general population due to the protein transition. Although animal-based foods are also a source of vitamins and minerals, it is possible to implement the protein transition without causing deficiencies. The committee is proceeding on the basis of a diet in which the current guidelines for fish and dairy are followed up and in which the consumption of meat is reduced. As the current diet is providing more than enough protein, a decrease in the total protein intake will not result in a protein or essential amino acid deficiency on average. However, the committee advises monitoring the intake of vitamins A, B2 and B12, calcium, iron (in women of childbearing age), iodine and fish fatty acids to ensure adequacy.

3.1 Approach

In this chapter, the committee focuses on the nutritional effects of the protein transition on the general (adult) population by discussing empirical research that supports a more plant-based and less animal-based diet and health (Paragraph 3.2), followed by the findings of modelling studies, based on both substitution studies and optimisation studies (Paragraph 3.3). Both empirical research and modelling studies have advantages and disadvantages and complement each other. Empirical research focuses on associations and effects based on actual consumption patterns. Modelling studies focus on theoretical shifts in diets. This makes it possible to study a wider range of changes than with empirical research. Lastly, the committee combines the findings of the different types of research per nutrient (Paragraph 3.4) and relates them to both the current intakes measured via the DNFCS[34,60] and the expected shift in intakes.

3.2 Empirical research into plant-based diets

The *Dutch dietary guidelines 2015* are based on systematic reviews of nutrients, foods and dietary patterns on the risk of chronic diseases.[28] In 2015, the committee concluded that there was compelling evidence that plant-based diets reduce the risk of coronary heart disease.[28] This conclusion was based on randomised controlled trials (RCTs), in which plant-based diets lowered blood pressure, and on cohort studies in which these diets were associated with a lower risk (~-25%) of the occurrence of coronary heart disease later in life.[61] Where the plant-based proteins from the guidelines are concerned, higher intakes are associated with a lower risk of various chronic diseases (see Figure 4). Animal-based protein sources such as red meat and processed red and white meatare associated with a higher risk of stroke, type 2 diabetes and colorectal

cancer. Dairy is associated with a lower risk of colorectal cancer (total dairy, milk) and type 2 diabetes (yoghurt), while fish is associated with a lower risk of coronary heart disease and stroke.[28,61-68]

In 2015, no research was available on ready-made meat, fish or dairy substitutes in relation to chronic diseases. The committee still did not find research of this nature either. The substitutes in question are (largely) made from plant-based proteins that have been marketed to replace meat, fish or dairy, and consumers use them as such. Therefore, the committee has conducted a systematic review of the nutritional composition of these products (see the Meat and dairy substitutes background document). Little research has been conducted into the physiological effects of these plant-based substitutes for animal-based protein sources yet.[69-71]

Adverse associations between red and processed meat and chronic diseases

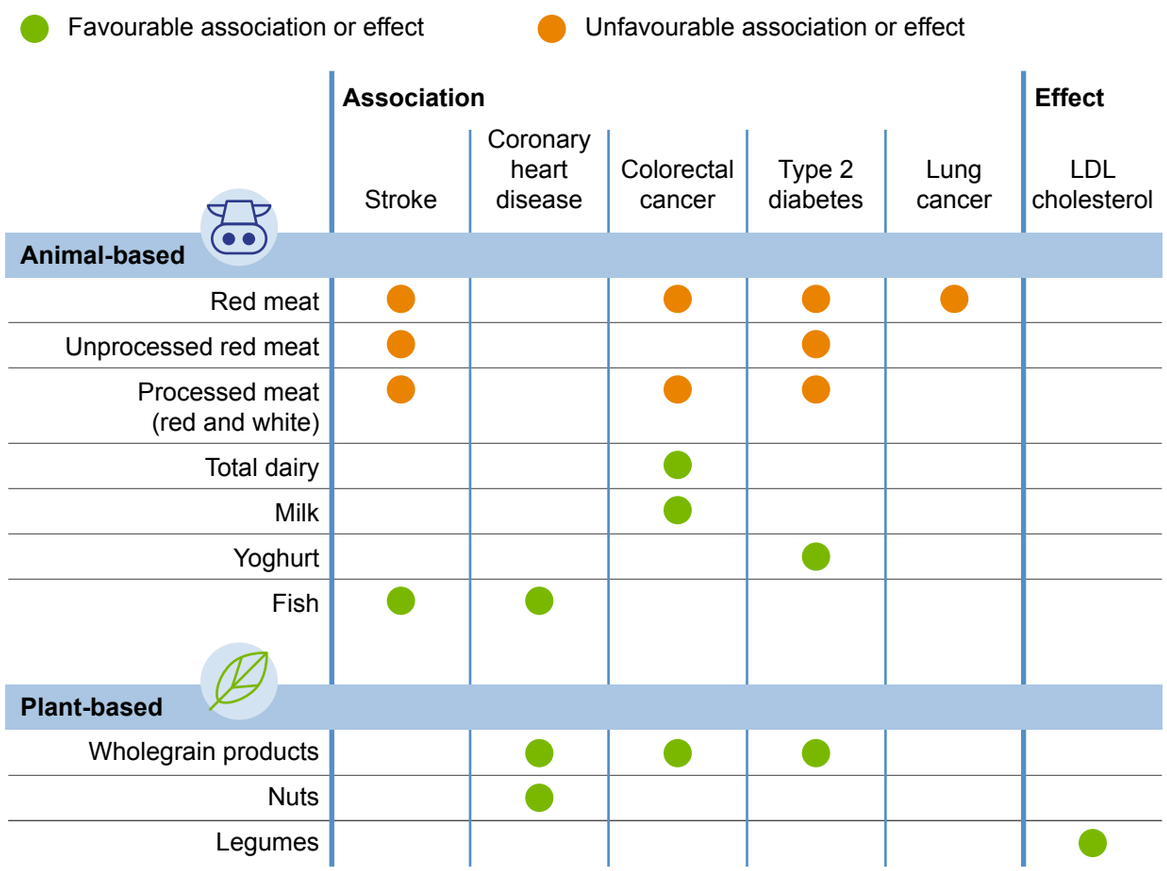


Figure 4 Association between protein sources and chronic diseases

For the purpose of this advisory report, the committee has systematically identified all research conducted into plant-based diets and chronic diseases since 2015 (see the Plant-based diets background document). This research shows that diets that are more plant-based are associated with a 10% to 25% lower risk of getting (and dying from) coronary heart disease, cardiovascular disease and type 2 diabetes. Also, more evidence

has emerged to support the conclusion that a vegetarian diet reduces systolic blood pressure by an average of 5 mm Hg compared to an omnivorous diet. Research conducted since 2015 shows that a vegetarian diet reduces LDL cholesterol and body weight (risk factors for diseases including cardiovascular disease and diabetes) to varying extents.

Review articles in which a distinction is made between 'healthy' and 'unhealthy' plant-based diets[72-75] show that healthy plant-based diets are associated with a lower risk of cardiovascular disease, while unhealthy plant-based diets are associated with a higher risk. These findings are generally confirmed by more recent cohort studies,[72,76-78] with exceptions.[79] These associations for healthy and unhealthy plant-based diets have also been found for type 2 diabetes,[80] total cancer[77] and breast cancer.[81] The studies in question did not look at fully plant-based diets. In these studies, the term 'healthy plant-based' was defined as diets that contain more whole grains, fruit, vegetables, nuts, legumes, tea and coffee, while the term 'unhealthy plant-based' was defined as diets that contain more 'white' grain products, potatoes, sugary drinks, fruit juice, sweet snacks and desserts.

The research available on plant-based food and muscle health focuses mainly on older adults (see Chapter 4) or on people who are working on muscle mass or function (bodybuilding or rehabilitation). Relatively little research (including intervention studies) has been conducted into the effect of plant-based and animal-based proteins and protein sources on bone health. Research into fracture risk was evaluated specifically for dairy products in the context of the *Dutch dietary guidelines 2015.* The conclusion was that an association between milk consumption and hip fractures was unlikely. No conclusions could be drawn about other associations between dairy products and bone health because of the lack of available research. In a recent observational analysis of almost 130,000 people from the United Kingdom, no association was found between a healthy or unhealthy plant-based diet and bone fractures.[77] A shift to a more plant-based diet, a fully plant-based diet in particular, could possibly be unfavourable for the risk of fractures, especially if accompanied by an inadequate intake of the nutrients that are important for bones (such as calcium and vitamin B12).[82] A systematic review (based on seven intervention studies in healthy adults) of the effects of soy and animal-based protein did not show any difference in markers for bone health.[83]

A recent systematic review concluded that the available research into total protein, animal-based protein or plant-based protein was inconclusive as regards any association with bone health. A higher intake may only be more beneficial than a lower intake for hip fractures. However, it remains unclear whether the protein intake should be higher than specified in the dietary reference values.[84]

3.3 Modelling studies into plant-based dietary patterns

Substitution models

In substitution studies, certain foods in a diet are replaced with other foods. The effects of this replacement on intake and possibly also on the adequacy of nutrients are then studied. Research by the National Institute for Public Health and the Environment (RIVM) into adults[85] used scenarios involving 30% and 100% less dairy and meat. Dairy and meat in the current diet (based on the latest DNFCS) were replaced by plant-based (partially fortified) foods appropriate for the consumption occasionin question, such as legumes, meat and dairy substitutes and peanut butter. Other animal-based products (eggs and fish) were not replaced.
The exact percentages of animal-based and plant-based proteins in the two scenarios are not known, but the proportion of animal-based protein was expected to be above 40% if dairy and meat were reduced by 30% and below 40% if they were reduced by 100% (see the Modelling studies background document).

Optimisation models

Modelling studies that focus on identifying the healthiest and most sustainable diet possible provide an insight into the food and food groups that ought to be consumed more or less (at group level) to meet the conditions set by the model (the optimisation model). Health factors that are often included in such modelling studies are dietary reference values or dietary guidelines. Environmental impact is another factor that is often included. Optimeal® and SHARP are two examples of optimisation models that are used in the Netherlands.[86,87] The SHARP model has been used to make calculations for the purpose of this advisory report (see the Consumption models text box on the next page and the SHARP background document).

Consumption models: Optimeal® and SHARP

The Optimeal® tool is owned by Blonk Consultants, a private party. It is used to generate a diet 'solution' based on a set of pre-specified criteria. Environmental indicators are obtained from the Agri-footprint database, which was developed by Blonk.

SHARP stands for environmentally Sustainable, Healthy (nutritionally adequate), Affordable (accessible while supporting the European agri-food sector), Reliable (stable in their supply) and Preferred (consistent with cultural norms and preferences).[88] The SHARP model identifies the optimal diet to achieve a particular outcome (such as environmental impact or nutritional value) and meet a number of prerequisites (such as feasibility). The modelled diet is identified by combinations of daily diets that are present within the dataset for comparable individuals or subpopulations (with the same gender, age or education, for example).[89] Therefore, the identified diets do not deviate extremely from the existing diet of the population. The health indicators are based on nutrient requirements and the *Dutch dietary guidelines*, while the environmental indicators are based on LCA data from multiple databases.[88]

When the committee used the SHARP optimisation model to analyse adults for the purpose of this advisory report, the prerequisite was for diets to have a 60% proportion of plant-based protein (compared to 40% in the current diet) with no change in energy intake. To ensure that the diet became or remained as healthy as possible, additional limit values were introduced for the healthiness of the diet based on a score derived from the *Dutch dietary guidelines 2015*.[28] The SHARP model chooses shifts that match the current diet as much as possible and in the same combinations.

On average, the modelled shift from animal-based to plant-based protein led to a diet that was better aligned to the *Dutch dietary guidelines* than the current diet is, even when no additional health limit values were included. According to these model calculations, therefore, the transition to 60% plant-based protein will lead to a diet that is healthier on average. Compared to the current diet, the consumption of vegetables, fruit, grains, dairy (excluding cheese), coffee and tea increased. The consumption of meat, cheese and eggs decreased, as did the consumption of other (sugary) drinks. Unless the model gave greater weight to the fish requirement, the amount of fish consumed decreased as well, which is not in line with the *Dutch dietary guidelines*. For a detailed description, see the Modelling studies and SHARP background documents.

3.4 The protein transition and nutrient supply

In this paragraph, the committee describes the nutrient supply provided by the current diet and the expected consequences of the protein transition on the nutrient supply. The committee used modelling studies described above to determine the expected consequences of the protein transition on nutrient supply. In so doing, the committee focused mainly on protein and on nutrients of which the intake might decrease as a result of the protein transition. An overview of the adequacy of the current intake of relevant micronutrients of the general population is provided in an RIVM report based on the DNFCS 2019-2021.[34] No data are available on the nutrient intake of people from the Caribbean Netherlands.[90] Similarly, only

limited dietary intake data are available for people with a migration background.[91,92]

3.4.1 Protein

The average protein requirement for healthy adults of all ages is 0.66 g/kg of body weight/day.[93] Strictly speaking, this requirement only applies to people with a healthy weight (the reference weight; in other words, the ideal weight for a certain height[29]). If the protein requirement in grams per day were to be calculated on the basis of *actual* body weight, the protein requirement would be higher for a person who is overweight or obese, while the requirement would be lower for a person who is underweight rather than a healthy weight. Therefore, the committee calculated the adequacy of protein on the basis of both the reference weight and the actual weight. The committee assumes that the requirements of overweight and obese people will lie somewhere in between. It based the requirement of underweight people on the (higher) reference weight.

Based on the reference weight, the current protein intake of the majority of the general adult population is higher than required. The vast majority (more than 90%) have a protein intake that is higher than the average requirement and more than 70% have an intake that is higher than the recommended amount (see Figure 5 on the next page).[34]

The calculations based on actual weight show that less than 10% of people have a lower intake than the average requirement, except women in age groups 30-39, 40-49 and 50-59 (12.9-14.2%). However, low intakes per kilogram of body weight were only found for overweight or obese women. In the calculations based on reference weights, the percentage is a maximum of 4.2% for women between the ages of 40 and 49. The committee assumes that the calculation of the requirement based on actual weight is an overestimation of the actual requirement for this group and does not consider the current protein intake in this group of women to be problematic.

Protein intake for most of the adult population is well above the average requirement

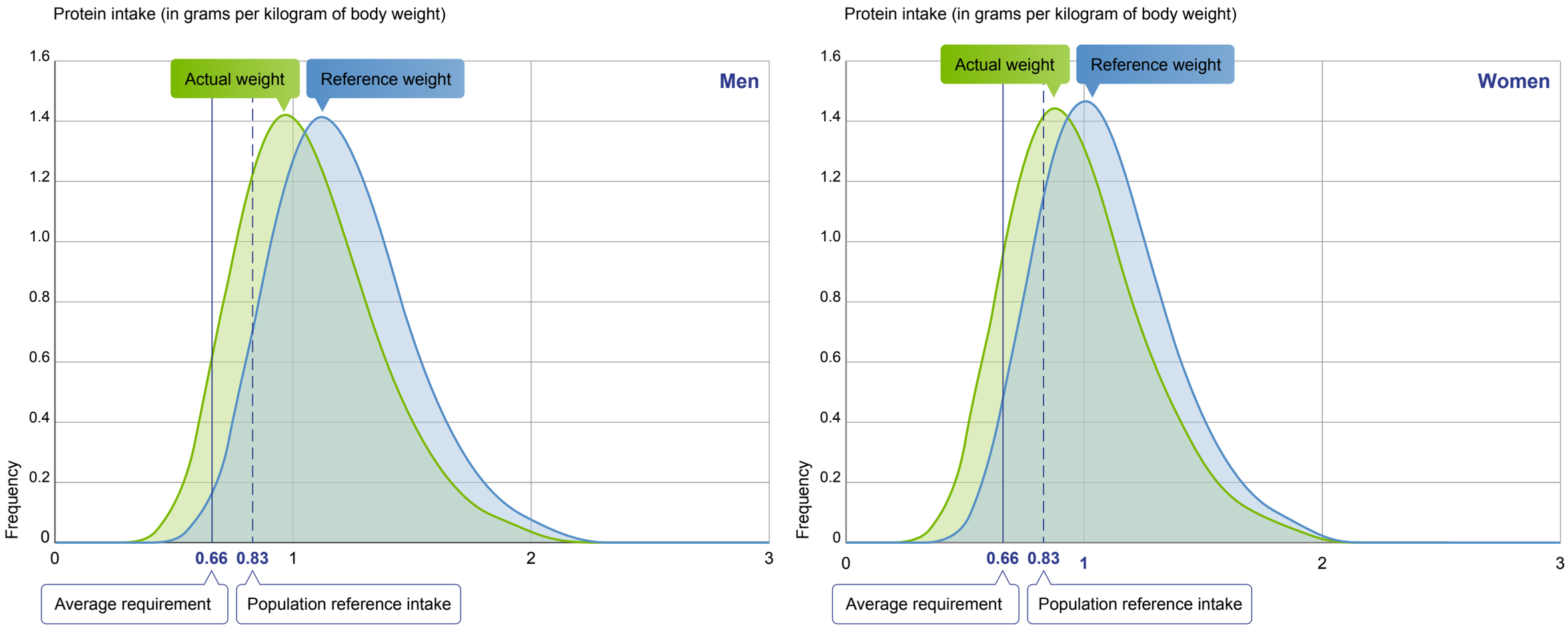


Figure 5 Distribution of protein intake among Dutch adults aged 18-69 (Dutch National Food Consumption Survey 2019-2021)[34]

In a number of model calculations and internal calculations in which the amount of total protein was not limited and the amount of energy was not changed, the shift to more plant-based protein resulted in a reduction in total protein.[1,39,85] The SHARP model analysis also showed that a modelled shift to 60% plant-based protein was associated with a 11%-13% decrease in total protein. Because the Dutch consume more than enough protein, a sufficient margin is in place to accommodate this decrease in protein consumption for most of the population. The same was also found in model calculations in which 100% of meat and dairy was replaced by

plant-based products.[85] This may be different for people whose protein intake is already low (or inadequate) (see Chapter 4).

Protein quality calculations are not included in most studies into the effect of consuming more plant-based and less animal-based food. The SHARP model showed that protein quality (calculated per meal) decreased the more plant-based and less animal-based a diet became, but this decrease could not be quantified. The RIVM substitution study in which 30% or 100% of meat and dairy was replaced by plant-based protein sources concludes that the supply of essential amino acids (and, as such, protein quality) is and will continue to be sufficient in a varied Dutch diet.[85,94] Therefore, the committee has determined that the effect of the protein transition on protein quality will not affect the majority of the Dutch population or only to a limited extent. Its arguments are as follows.
The Dutch population consumes a varied diet with an excess of protein, as is the case in many Western countries.[39,95] Nutrition education to the public is based on the 'recommended amount' of protein (see Chapter 2), which is higher than necessary for most people. Moreover, the average protein consumption in the Netherlands is higher than the recommended amount. If the protein intake were to be reduced by 10%-20%, it would still be sufficient across the population. Even if the protein quality is not optimal, the total higher protein intake will still ensure that people ingest enough of the essential amino acids they need.

In this context, the committee also observes that products that contain extra protein (such as shakes and bars), which are often aimed at recreational athletes, are not essential components of a healthy diet.

In conclusion, the committee is of the view that the protein intake of the general population is more than sufficient. As such, a shift to a more plant-based and less animal-based diet across the population will not lead to problems in the adequacy of protein and essential amino acids.

3.4.2 Vitamin A

Given the current intake, the vitamin A intake of the general population is already a point of attention. The current average intake of vitamin A (expressed in retinol equivalents (RE)) of groups aged 14 and over of the general population is somewhat low compared with the dietary reference value.[34] However, RIVM concluded in 2020 that there were no concrete indications that vitamin A intake was a concern, because there were no known cases of health problems associated with these low intakes.[37,96]
The most important sources of RE in the current diet are dairy (25%), fats and oils (16%), vegetables (19%) and meat (11%).[37] In Dutch modelling studies in which 30% of dairy and meat was replaced by plant-based alternatives, there was no statistically significant change in average vitamin A intake in adults.[85] A modelled replacement of 100% of meat and dairy consumption (without the replacement of fish and eggs) resulted in a

level of vitamin A intake that would be below the average requirement for the majority of adults.[85]

Based on the current intake of the general population, the committee concludes that attention is already warranted for the vitamin A intake. Therefore, monitoring continues to be important.

3.4.3 Vitamin B2

The current vitamin B2 intake of the general population is somewhat low compared with the reference values, especially among women.[34,37] Despite low intakes among adults, there are no indications of public health problems. However, health risks cannot be ruled out. In 2020, RIVM concluded that research into the nutritional status of vitamin B2 could provide more insight.[37]

The main source of vitamin B2 is dairy (38%), but meat provides vitamin B2 as well (11%).[37] The replacement of 30% dairy and meat by plant-based alternatives did not result in any statistically significant change in vitamin B2 intake in adults. On average, a 100% replacement did not lead to an inadequate estimated intake for adults either.[85] This can be explained in part by the fact that modelling took place on the basis of dairy substitutes enriched with vitamin B2. Consuming a diet according to the Wheel of Five leads to a vitamin B2 intake at the level of the individual recommended amounts, even if no meat is consumed.[97]

According to the committee, vitamin B2 would not appear to be a matter for concern from the perspective of the protein transition, provided the recommended amount of dairy is consumed. If a dairy substitute is chosen, it is important to choose a product that is enriched with vitamin B2.

3.4.3 Vitamin B6

Vitamin B6 is supplied by many different food sources, both animal-based and plant-based.[37] Although the current diet can lead to a low intake among women,[34] there are no indications of public health problems as a consequence. In 2020, RIVM concluded that research into the nutritional status of vitamin B6 could provide more insight into the degree of adequacy.[37] Vitamin B6 was not evaluated in the modelling studies. The committee concludes that vitamin B6 is not a matter for concern from the perspective of the protein transition, because vitamin B6 is supplied by many different food sources.

3.4.4 Vitamin B12

The current vitamin B12 intake of the general population is adequate.[34,37] In the current diet, vitamin B12 is mainly supplied by dairy (39%), meat (26%), fish, crustaceans and shellfish (8%) and eggs (6%).[37]

In general, the prevalence of vitamin B12 deficiency increases when the consumption of animal-based foods decreases.[98] When 30% of dairy and

meat was replaced by plant-based alternatives, the vitamin B12 intake decreased, but continued to be adequate. However, the B12 intake was too low when 100% of dairy and meat was replaced.[85] In the diet calculated by the SHARP model on the basis of 60% plant-based protein, the amount of vitamin B12 decreased, but was still higher than the average requirement, even if the amount of protein was the recommended amount at the most. The committee concludes that the current intake of vitamin B12 is adequate, but must be monitored in light of the protein transition.

3.4.6 Calcium

The current intake of calcium of the general adult population (aged 18-79) is low compared with the dietary reference value.[34] It is difficult to evaluate the adequacy of the calcium intake of women aged 50 and over and men aged 70 and over.[34,37] The dietary reference values for calcium for adults (women up to the age of 50 and men up to the age of 70) are based on the need to maintain levels of calcium in the body. There does not seem to be an indication of a public health problem in the latter groups. It is not yet possible to measure the nutritional status of calcium. Therefore, RIVM recommends that further research be conducted into this.[37]

With an average contribution of 57%, dairy is the main source of calcium for the Dutch population, followed by water from non-alcoholic drinks like coffee, tea, juice and soft drinks (11%), and grains (7%).[37]

Dutch modelling studies in which 30% of dairy and meat intake was replaced by plant-based alternatives showed a decrease in the calcium intake compared to the usual diet.[85,94] However, the decrease was limited. This could be explained in part by the fact that commercially available, plant-based dairy substitutes are often enriched with calcium. However, the decrease was approximately 25% when replacing 100% of dairy and meat.

Other Dutch modelling studies also show that the supply of calcium decreases in a diet with less dairy than the current diet.[99,100] The analyses performed for the purpose of this advisory report, based on the shift from 40% to 60% plant-based protein, show that the average calcium intake remained above the average requirement of 750 mg/day for women up to the age of 50 and men up to the age of 70 in the event of a decrease in total protein by 10%-15% (see the SHARP and Modelling studies background documents).

The committee concludes that if dairy consumption decreases as a result of the protein transition (without calcium being supplied by other foods, for example in the form of fortified dairy substitutes), the calcium intake will decrease further. The committee recommends, with regard to the protein transition, maintaining dairy consumption at the level of the recommendations. However, no more than necessary should be consumed. If a dairy

substitute is chosen, it is important to choose a product that is enriched with calcium.

3.4.7 Iron

Based on the current diet, the iron intake of the general population is adequate for women aged 51 and over and also for men. However, the iron intake for girls and women of childbearing age is a point of attention.[34,37] Approximately 29% of girls and women aged 19-50 have an intake under the average requirement. For girls aged 14-17, this percentage is estimated to be 77% and possibly higher.[34,37] RIVM deems further research into the effects of low iron intakes on the level of public health necessary.[37] The iron requirement of girls and women is mainly determined by iron losses (via menstruation) and varies considerably from one individual to another.

Important food sources of iron are grains (26%), meat (14%), vegetables (9%), sweets (6%) and supplements (8%).[37] Heme iron (from animal-based sources) is easier to absorb than non-heme iron (from plant-based sources).[101] In a Dutch modelling study for the Netherlands in which 30% or 100% of dairy and meat intake was replaced by plant-based alternatives, the iron intake (in the form of non-heme iron) increased compared with the usual diet.[85] The results depended in part on whether the plant-based alternatives had been enriched.[85] The analyses performed for the purpose of this advisory report, based on the shift from 40% to 60% plant-based protein, show that the total iron intake increased for the scenario without protein requirements (the protein intake decreased). On average, total iron levels were above the average iron requirement and also above the higher average iron requirement of girls and women of childbearing age. Although the increase was mainly due to non-heme iron, the committee does not expect these shifts to have any substantial consequences for the adequacy of total iron.[57]

Based on the current diet, the committee concludes that attention is already warranted for the intake of iron among women of childbearing age. The protein transition does not alter this fact.

3.4.8 Iodine

In 2020, it was concluded that the adequacy of iodine had decreased, but was still adequate.[37,102] However, the iodine intake has fallen by about one-third since 2006-2007.[103] Based on a status study into adults between the ages of 31 and 50 in the Lifelines cohort study, RIVM concluded that the iodine adequacy for men was still good in 2020-2021. However, the same was only barely true for women. Therefore, it is important for the iodine intake not to decrease any further.[103] Iodine is mainly supplied by iodised table and bread salt and dairy products. However, iodised bread salt is not always used in organic bread. Fish is a good source of iodine too, but average fish consumption is low.[103]

A shift to fewer animal-based and more plant-based protein sources could reduce the iodine intake via dairy products and added salt and increase it via bread (and possibly also seaweed), but information about the impact of the protein transition on iodine adequacy is not available at this stage. The iodine adequacy is preferably evaluated through status studies, because the intake of salt and table salt is difficult to measure. Modelling studies do not generally report on iodine.

Based on the current diet, the committee concludes that iodine is a point of concern among women and that shifts as a result of the protein transition are unknown. With this and the protein transition in mind, it is important to monitor the adequacy of iodine through status studies.

3.4.9 Zinc

The current zinc intake of the general population is adequate.[34,37] Zinc is mainly supplied by meat (23%), dairy (22%) and grains (20%).[37] In a Dutch modelling study in which 30% of dairy and meat intake was replaced by plant-based alternatives, the zinc intake decreased but remained adequate. When all dairy and meat (100%) were replaced by plant-based alternatives, the zinc intake decreased to a level below the recommended amount. Added to this, phytate as an inhibitory factor for zinc absorption plays a greater role in this scenario. However, the extent of this role is difficult to estimate.[85] The committee does not expect the protein transition to give rise to problems with the adequacy of zinc for the general population.

3.4.10 Fish fatty acids EPA and DHA

The intake of fish fatty acids (EPA and DHA) of the general population is too low. The median intake (107 mg/day) is well below the recommended intake (‘adequate intake’ – see the Dietary reference values text box) of 200 mg/day.[37] A total of 40% of the general population does not consume fish once a week, as recommended in the guidelines.[28] Although fish has health benefits, consuming fish is more environmentally harmful than consuming plant-based protein sources. With the environmental impact in mind, the SHARP model initially generates a diet that contains less fish and fish fatty acids, unless the importance of health outweighs that of the environmental impact. The committee concludes that fish fatty acids are a point of attention from the perspective of both the current intake of the general population and the protein transition. The committee recommends following up the advice for fish consumption, but the general population should not consume more fish than necessary.

3.4.11 Dietary fibre, saturated fat and salt

Optimisation studies in Dutch adults[86,99,104,105] and children[99] among the general population show that a more plant-based diet is generally healthier than the current diet. These optimised diets are characterised by a higher intake of vegetables, fruit and legumes and a lower intake of

meat, dairy, sugar-containing drinks, sweets and snacks. A diet shift of this nature will result in higher fibre intakes and lower intakes of saturated fat, and salt that has been added to products. In substitution studies, the replacement of 30% or 100% of dairy and meat intake by plant-based foods also led to improvements in saturated-fat and fibre intake.[85,94] Also, SHARP model calculations showed that the average amount of saturated fat and salt (sodium) added to products decreased in the modelled diet compared to the current diet. The amount of dietary fibre and unsaturated fat increased. These shifts are desirable, because average saturated fat and salt intakes are currently too high, while the fibre intake is too low.[37] Fibre, salt and saturated fat play an important role in the development of chronic diseases. Given their importance to public health, the EFSA has prioritised them as elements of a food choice logo for consumers.[106] They will be included in the Nutri-Score to be introduced in the Netherlands from 2024, alongside the percentage of vegetables, fruit and legumes.[107]

3.5 Substitution and optimisation studies both point in the same direction

If the consumption of animal-based protein sources decreases, it will be more difficult to achieve the dietary reference values for nutrients that are mainly supplied by animal-based protein sources. However, the intake of nutrients from plant-based sources will increase. This is confirmed by the results of both optimization and substitution studies. Logically, the findings of substitution studies depend very much on the foods that substitute each other. For example, the substitution of meat and/or poultry will lead to lower intakes of various vitamins and minerals if meat and/or poultry is not substituted with other foods that provide these nutrients.[108-110] Red meat is a good source of vitamin B12, heme iron and zinc. Legumes do not contain vitamin B12 or heme iron and are a poorer source of zinc than meat is. A large international substitution study in 150 countries shows that a decrease (25%, 50%, 75% and 100%) in animal-based products and their substitution with a 2/3 share of legumes and a 1/3 share of vegetables generally led to improvements to the nutrient supply in countries with medium to high incomes. This did not apply to calcium and vitamins B2, B5 and B12 in the event of the 100% substitution of animal-based products.[111]

Besides substitutions based on the type of product – meat versus legumes, nuts and other (largely) unprocessed products, for example – the results of model calculations are also determined in part by the extent to which plant-based alternatives to meat and dairy are enriched with nutrients that the substituted products supply. Besides Dutch studies,[85,94] other European substitution studies show that fortified plant-based substitutes can play a role in maintaining an adequate nutrient intake.[112]

The EAT-Lancet diet, an optimised food pattern that respects the planetary boundaries, also shows that it is more difficult to achieve the dietary

reference values for nutrients that are mainly found in animal-based products.[113] This diet has been criticised for providing insufficient nutrients, especially for women of childbearing age (particularly iron).[114] Although the committee also defines iron as a point of attention for this group of women with the protein transition in mind, it is not possible to derive conclusions about deficiencies in a population on the basis of a modelled diet as such. This requires information about the distribution of nutrient intakes compared to the distribution of requirements, combined with status studies (see Paragraph 2.4). In general, the findings of optimisation studies often lead to an overestimation of potential nutrient deficiencies, because these studies generally assume that a diet must provide the recommended daily amounts (population reference intake) of nutrients for everyone, which is not the case in reality.

Like legumes and nuts, ready-made meat and dairy substitutes usually play a minor role in optimisation models compared to substitution models. In many modelling studies, feasibility conditions are imposed on modelled new diets. This requires the modelled diet to be as similar as possible to the existing diet. As a result, the model is more likely to select products that are already being consumed in existing diets, or in higher quantities, than products that are being consumed less. Current consumption of meat and dairy substitutes is not high and Dutch modelling is (still) based on food consumption 10 or even 25 years ago, when the consumption of plant-based meat and dairy substitutes was even lower than it is now (see the Modelling studies background document).

Although the two types of modelling studies are based on different assumptions, they support each other's findings: nutrients that are the first to become 'critical' in an optimisation model will usually show decreases in substitution models based on the same substitutions. Further research will need to be done to establish whether these decreases would lead to deficiencies.

3.6 Summary and conclusions

Table 1 summarises the nutrient-supply findings for the general adult population from the perspective of the protein transition.

Table 1 Nutrients for attention in the protein transition for the general population and for specific groups within the general population

	Current intake[1]	Protein transition[2]
General population	Vitamin A Vitamin B2 Calcium Fish fatty acids	Vitamin B12
In addition to the above, the following applies for the groups below:		
Women	Iodine	
Women and girls of childbearing age	Iron	

[1] Based on the Dutch National Food Consumption Survey 2019-202134
[2] These nutrients will become a point of attention with regard to the protein transition

The committee concludes that most of the Dutch population will have a healthier diet after the shift to a more plant-based diet, because the new diet will be more in line with the *Dutch dietary guidelines*. Healthy plant-based diets (a high intake of whole grains, fruit, vegetables, nuts and legumes) are associated with a lower risk of cardiovascular disease.[72-75] These associations have also been found for type 2 diabetes,[80] all types of cancer[77] and breast cancer.[81] To date, there have been no indications that the shift to a more plant-based diet will have negative consequences for the bone health of the general population.

Diets that have been optimised for health and environmental impact usually consist of a higher proportion of vegetables, fruit, legumes and a lower proportion of (red) meat, dairy and sugar-containing drinks. As such, they will include more fibre and less saturated fatty acids, sugar and possibly salt, amongst other things. Calculations using the SHARP model showed that the shift to a diet with 60% plant-based protein instead of 40% would be more in line with the *Dutch dietary guidelines* than the current diet is, even without additional requirements based on dietary reference values or dietary guidelines.

The current *Dutch dietary guidelines* already provide important directions for implementing the protein transition. Fish and dairy consumption contributes to complying with the dietary reference values for calcium and vitamin B2 (dairy) and fish fatty acids (fish), as well as to good protein quality. However, it is not necessary to consume more dairy and fish than the amount specified in the guidelines or more than necessary to comply with the dietary reference values. When consuming fish, it is important to choose fish species that are not being overfished and that are being farmed in an environmentally friendly manner.[115] In the current protein-overconsumption situation, meat consumption can be reduced for most people, as can dairy consumption for people who are consuming well above the dairy recommendation, without endangering nutrient supply.

04
the protein transition for specific groups

The committee studied the health effects of the protein transition for a number of specific groups in the general population. The dietary reference values are or may be higher or more difficult for some groups to achieve. The committee does not see any point of attention for people with chronic conditions or obesity, children or the elderly other than the nutrients and nutrient intakes that are considered points of attention for the general adult population (vitamins A, B2 and B12 and calcium, iron, iodine and fish fatty acids). However, more attention should be paid to pregnant women, breastfeeding women and those with low protein and energy intakes.
If people from these groups want to consume more plant-based food, they must be well-informed or have proper guidance. The committee feels it is important to improve monitoring of the dietary intake by and nutritional status of all the specific groups mentioned.

4.1 Specific groups of the general population

Below, the committee discusses the consequences of the protein transition for groups for which nutrient requirements are higher, or for whom dietary reference values or recommendations are more difficult to achieve (because food consumption is low). These are people with chronic conditions or obesity, children, older adults, pregnant women, breastfeeding women and people with low protein and energy intakes. These groups may overlap in part.

Like the general population, the diet that the groups mentioned consume with regard to the protein transition will generally be more conducive to the reduction of the risk of chronic diseases (like cardiovascular disease). The nutrients and nutrient intake that are identified as points of attention in respect of the general population based on the current diet (vitamins A and B2 and calcium, iron, iodine and fish fatty acids) are also relevant for the specific groups mentioned in this chapter. This chapter focuses on specific points of attention in addition to those for the general population.

The committee used additional intake data for a number of groups that are not included in the DNFCS (pregnant and lactating women and elderly people over the age of 80) or that are not reported on separately (people with chronic diseases and people with low protein and energy intakes).[116-118]

4.2 People with chronic diseases or obesity

Guidelines and dietary reference values

The *Dutch dietary guidelines 2015*[28] also apply to people with type 2 diabetes[119] and cardiovascular disease caused by atherosclerosis[120] or obesity. However, slightly stricter guidelines on fish apply for people with cardiovascular disease (fish once to twice a week instead of once).[120] Dietary reference values are derived for healthy people with a healthy weight. No specific values are available for other groups and the dietary reference values of healthy people are usually also applied to other

groups. It is possible that certain diseases and/or medication use or obesity could influence the requirements for nutrients, but not enough is known about this. Guidance from a dietitian is important for groups of people who are receiving specialist treatment for multiple problems.

Intake

The protein intakes of people who are overweight are not lower than the intakes of people with a healthy weight, but the adequacy is not possible to clearly determine because the protein values have been derived for people with a healthy weight[34] (see Paragraph 3.4.1). The same applies for the other nutrients. People with chronic diseases (diabetes, cardio-vascular disease and lung diseases) do not seem to have lower protein intakes than the healthy adult population either. This is shown by the Lifelines cohort study, which looked at the dietary intake data of more than 118,000 people in the northern Netherlands.[116] The cohort was representative of people in the northern Netherlands, although people with a low level of education were under-represented.[117] The intake data were collected between 2006 and 2013 by means of a food frequency questionnaire. Because the method used to measure protein intake was different to that used in the DNFCS (a food frequency questionnaire is a less suitable way of assessing the adequacy of nutrient intakes), some caution is advised when comparing data with the DNFCS (see the 'Lifelines' background document). According to the DNFCS Older Adults (community-dwelling) 2010-2012, vitamin and mineral intakes among people with chronic conditions does not differ substantially from that of people without chronic conditions either.[121]

Conclusion regarding people with chronic diseases or obesity

Although little specific data are available about the (very diverse) group of people with chronic diseases and obesity, the committee concludes that the same benefits and points of attention apply to this group as for the general population.

4.3 Children from the age of one

Uncertainties about estimating the adequacy or inadequacy of nutrient intake are greater for children than adults. In general, dietary reference values for children are less well substantiated, because they are based on less research than the dietary reference values for adults are. Added to this, nutrient requirements can vary greatly depending on a child's growth rate. Also, far fewer modelling studies and of a less extensive nature have been conducted for children than for adults, so the consequences of shifts as part of the protein transition are more difficult to estimate.

Protein

Because they are growing, children have a higher protein requirement per kilogram of body weight than adults do.[93] However, the protein intake of children among the general population is adequate; in all cases, the percentage of children whose intake is below the average requirement is

less than 5%.[34] Therefore, few protein-related problems are expected as the result of a shift to a more plant-based and less animal-based diet. In substitution models in which 30% or 100% of dairy and meat was replaced by plant-based alternatives for young children (aged 2-6), the total protein intake decreased, but continued to be adequate: the percentage of children whose intake was below the average requirement was 0%.[94]

Vitamin A

In the current diet, low intakes of vitamin A are reported for children aged 14 and over. The same applies for adults.[34] However, no health problems are known in relation to these low intakes (see 3.4.2).[37,96] No data are available on the consequences for Dutch children of a change in vitamin A supply as a consequence of one the protein transition. Based on the current intake of the general population, including children, the committee concludes that attention is already warranted for the vitamin A intake. Therefore, monitoring continues to be important.

Vitamin B2

It is difficult to estimate the adequacy of vitamin B2 for boys aged 14 and over, because the average intake is below the adequate intake.[34] Intakes seem to be adequate for the other groups of children. No data are available on the consequences for Dutch children of a change in vitamin B2 supply as a consequence of the protein transition. According to the committee, vitamin B2 would not appear to be a point of concern from the perspective of the protein transition, provided the recommended amount of dairy is consumed. If a dairy substitute is chosen, it is important to choose a product that is enriched with vitamin B2.

Vitamin B6

It is difficult to estimate the adequacy of vitamin B6 for girls aged 14 and over, because the average intake is below the adequate intake.[34] Intakes seem to be adequate for the other groups of children. No data are available on the consequences for Dutch children of a change in vitamin B6 supply as a consequence of the protein transition. Vitamin B6 is supplied by many different food sources. Accordingly, the committee does not believe that vitamin B6 will be a point of concern with regard tothe protein transition.

Vitamin B12

The current intake of vitamin B12 of Dutch children is adequate.[34,37] When 30% or 100% of dairy and meat was replaced with plant-based alternatives, the vitamin B12 intake decreased, but remained adequate.[94] The committee concludes that, just as for adults, the current intake of vitamin B12 is adequate, but must be monitored with regard to the protein transition.

Calcium

Calcium is important for growing children as well. The calcium intake of boys up to and including the age of eight and girls up to and including the age of three would seem to be adequate.[34] Adequacy is not possible to assess for older children (the average intake is below the adequate intake).[34] Dutch modelling studies on children between the ages of two and six, in which 30% of dairy and meat was replaced by plant-based alternatives, showed a decrease in the average calcium intake for girls compared to the usual diet.[94] The same applied for boys when a 100% replacement was modelled. Just as it does for adults, the committee recommends maintaining dairy consumption at the level of the recommendations. However, no more than necessary should be consumed. If a dairy substitute is chosen, it is important to choose a product that is enriched with calcium.

Iron

Low iron intakes are observed according to the current diet of girls aged 14 to 18.[34] This is a higher proportion than the one for women aged 19 to 50: a total of 77% of the group of girls aged 14 to 18 have an intake below the average requirement. This point of attention applies in respect of the current diet; the protein transition would not seem to influence this situation much. In modelling on children between the ages of two and six, in which 30% or 100% of dairy and meat was replaced by plant-based alternatives, the total estimated intake of iron remained sufficient.[94]

The committee concludes that the intake of iron for girls of childbearing age is already a point of attention in respect of the current diet; this does not change from the perspective of the protein transition.

Conclusion regarding children

As regards nutrients that are also a matter for attention for adults among the general population, the committee particularly sees the intake of iron as a specific matter for attention for girls aged 14 and over. This is already the case for current intakes.

4.4 Pregnant and breastfeeding women

In 2021, the Health Council of the Netherlands concluded that it is more difficult to limit the consumption of animal-based products during pregnancy[122] because the dietary reference values for protein, vitamins A, B2 and B12, calcium, iodine and zinc etc. are higher for pregnant women.[48-50,93] The Health Council of the Netherlands is still to derive nutritional recommendations for breastfeeding women,[51] but the dietary reference values for various nutrients (protein, vitamins A, B2 and B12, iodine and zinc) are also higher for this group than for non-pregnant women and non-lactating women.[48-50,93] Particularly, the nutritional reference value for vitamin 12 is relatively high for lactating women.

The nutritional guideline for fish is also higher for pregnant women (twice per week) than for men and non-pregnant women (once per week).[122]

Calcium suppletion applies for the second half of pregnancy if the calcium reference value is not being met by the diet being consumed.[122] Due to the harmful effects of excessive vitamin A intake on the development of the foetus, liver consumption is advised against for pregnant and lactating women. The same applies for the use of nutritional supplements that are not specifically intended for pregnant women, because the doses can be too high.

Very few good intake data are available for pregnant and breastfeeding women, because these groups are not represented in the DNFCS. However, RIVM does monitor literature on this subject: a recent systematic review article found 54 study populations with Dutch data on dietary intake or nutritional status for pregnant women.[118] Most of these studies focused on alcohol consumption and folic-acid use and the data were limited in terms of quantity, quality and representativeness. Nonetheless, the authors cautiously concluded that the intakes of protein, vitamins A, B1, B2, B6 and B12, iron and calcium would seem to be adequate.[118] However, most women probably do not achieve the recommended amount of 1,000 mg/day calcium in the second half of pregnancy. No published studies were found on the intake of iodine, copper and zinc.[118] However, it is known that the adequacy of iodine has decreased in the Netherlands over the years and that the iodine intake should not decrease further. Iodine is especially important for the development of the unborn child in pregnant women.[122] The authors identified low fish consumption as a matter for concern, as well as a low intake of fruit and vegetables and (high) intakes of alcohol, sugary drinks and salt. Many pregnant women take multivitamins.[118]

No suitable Dutch studies were found on breastfeeding women.[123] Besides the lack of good data on nutrient intake or status, there are no data from Dutch research into the consequences of the protein transition for the intake of nutrients either.

Conclusion regarding pregnant and lactating women

Just as it did for the general population, the committee concludes that the intakes of vitamins A, B2 and B12, calcium, iron, iodine and fish fatty acids of pregnant and breastfeeding women warrant attention based on current intakes. Nutrient requirements are higher for pregnant and lactating women than for non-pregnant and non-lactating women. This makes it more difficult to limit animal-based products. There is a lack of intake data for these groups in general and lactating women in particular. It is also important for pregnant women not to exceed the safe upper limit for vitamin A and iodine intake.[122] The dietary reference value for vitamin B2 is a particular point of attention for lactating women, because this is even higher than for pregnant women.

4.5 Older adults

Older adults up to the age of 79 are represented in the 2012-2016 and 2019-2021 DNFCS. Vitamin and mineral intakes would generally appear to be just as adequate for adults aged 71-79 as for adults under the age of 70,[34] except for vitamin B6 and calcium (see below). The latest data for community-dwelling older adults aged 80 and over date back to 2010-2012. They show that the average intake of minerals among men and women aged 80 and over is lower than among 70-79-year-olds in the same study.[121] However, it is not known whether this leads to differences in nutrient adequacy between the age groups. While the DNFCS covers older adults up to the age of 79, modelling studies combine the results of adults of every age. As such, it is not possible to draw specific conclusions about the older-adult subgroup.

Proteins

The dietary reference value for protein for healthy older adults is not higher than the reference value for younger adults.[29] However, the (absolute) amount of protein required may be more difficult for older adults to achieve if there food consumption decreases.

Scientific organisations are calling for consideration to be given to the loss of muscle mass and muscle strength (sarcopenia) in the elderly.[124,125] These individuals may have a higher protein requirement.[124-126] Available studies into muscle function focus mainly on older adults or people who are trying to build muscle. Studies into the type of protein intake among older adults often focus on preventing the loss of muscle mass and strength.[29] Two out of five observational studies from a review article on vegetarian and vegan diets in adults (aged 60 and over) found a favourable association for animal-based food sources. One of the observational studies found a favourable association for plant-based food sources, while two of them found no association with muscle mass.[127] The studies varied in terms of study populations, the amounts (types) of protein studied and outcome measures. Intervention studies (five studies into short-term effects) into (alternative) plant-based protein sources and muscle mass and strength in older adults also reveal a mixed picture.[127,128] Based on these data, the committee does not see consistent indications to show that the protein transition would cause muscle health issues.

Based on the data from the latest DNFCS, it would appear that, on average, protein intake does not decrease with age; among women, protein intake is actually higher in the 60-79 age group than in the younger age group (30-59). Among men, protein intake does decrease slightly with age; in the 18-29 age group, just 1.2% have an intake below the average requirement, compared with 6.9% in the 70-79 age group.[34] The 80 and over age group falls outside the scope of the latest DNFCS, but was included in a slightly older DNFCS (2010-2012).[121] This shows that the protein intake per kilogram of body weight among relatively healthy elderly people aged 80 and over who live at home is barely any lower than that among elderly people in the 70-79 age group.

Intake data were also obtained from the Lifelines cohort study[116,117] (see the Lifelines background document). These data show a slightly higher percentage of people aged 80 and over (with and without chronic diseases) with an intake below the protein value compared with younger age groups. This applies mainly to women (around 15%); a lower percentage of men have an intake below the reference value (4-12%).

As regards protein quality, the committee concludes that attention is needed for elderly people whose protein intake is low, namely a protein intake equal to or lower than the individual protein requirement. Because the individual protein requirement is not (or never) known, protein intake is compared with the population reference intake. Protein quality gains in importance when protein intake is low or too low. It can be (more) difficult for the elderly to consume bigger quantities, especially bigger quantities of plant-based foods.

Calcium

A higher calcium dietary reference value applies for women aged 50 and over and men aged 70 and over compared to younger adults.
The reference value is higher because of the advise of vitamin D suppletion for these groups[129] and because sufficient calcium intake is vital for the effectiveness of vitamin D suppletion on bone health.[49] People who consume little or no dairy need a combination of vitamin D and calcium suppletion.[28] It has not been possible to arrive at a conclusion about the current adequacy of calcium in these groups, because the median intake was below the adequate intake. Dutch optimisation studies are available for adults up to the age of 79, but they do not cover the higher calcium reference value for women aged 50 and over and men aged 70 and over. The same applies for the analyses ensuing from the SHARP study conducted for the purpose of this advisory report. However, it was found that it becomes more difficult for the general population to achieve the calcium reference values if their diet contains less dairy.

Vitamin B6

Vitamin B6 intake is lower for the 71-79 age group than for younger age groups. A total of 18.9% of men aged 71-79 have an intake that is below the average requirement.[37] This is explained in part by the fact that the average requirement for men aged 50 and over is higher than for women and younger men. However, RIVM does not consider these low intakes a matter for concern. Like the other age groups, no data are available about the development of vitamin B6 intake as a result of the protein transition. Vitamin B6 is supplied by many different food sources. Accordingly, the committee does not believe that vitamin B6 will be a matter for concern with regard to the protein transition.

Vitamin B12

On average, vitamin B12 intake among older adults is no lower than among younger adults. However, a vitamin B12 deficiency is still more

common in the former group. The prevalence of reduced vitamin B12 blood levels in elderly people over the age of 70 is estimated at 10% or higher.[130] In most cases, however, this is the result of the poor absorption of vitamin B12 (in 70% of cases) rather than inadequate intake (15%).[98,130] In many cases, this does not lead to any problems. Vitamin B12 deficiency is associated with anaemia and neurological problems.[98,130] It is not known whether the protein transition could influence the bioavailability of vitamin B12. Specific medical advice applies to elderly people who have these absorption problems.[98]

Conclusion regarding older adults

Because of the current intakes, but also due to the protein transition, the calcium intake is more of a point of attention in respect of older adults than younger adults. This is mainly because of the higher calcium reference value. Sufficient calcium intake is important for the effectiveness of vitamin D supplements for bone health. Besides this, a reduced absorption of vitamin B12 in the elderly in general is a matter for attention.

4.6 People with low protein and energy intakes

Guidelines and dietary reference values

When establishing the protein values, the Health Council of the Netherlands stated that specific subgroups could possibly benefit from a higher protein intake than necessary for the general healthy population.[29] For example, patients in hospitals, nursing homes or rehabilitation centres, the elderly with home care, or people with risks factors for malnutrition (people who are less mobile, who have a low appetite or depression and people who are cognitively impaired, for example) may have a low protein intake compared to the protein intake requirement. Low protein intake is usually accompanied by low energy intake.[131] These groups can also lose protein due to acute or chronic diseases, leaving them with an increased protein requirement.[125] Specific guidelines are available for people who have or are at risk of malnutrition and who need specialist guidance on nutrition.[125,132] For example, the dietary guidelines of the European Society for Clinical Nutrition and Metabolism (ESPEN) 2014 advise a protein intake of 1.2 to 1.5 g/kg of body weight for malnourished patients and for people at risk of malnourishment. The objective here is to support maintained muscle mass and strength.[125,133]

Intake

Just a limited amount of literature is available on the dietary intake of the groups above. Data that are now quite old, from the DNFCS 1998[134], showed that the protein intake per day among older adults in care homes and nursing homes was much lower (0.8-0.9 g/kg of body weight) than among elderly people living at home (1.03-1.11 g/kg of body weight) and among vulnerable elderly people (1.0-1.04 g/kg of body weight).[135] At the time, the protein intake of 21% and 35% of the elderly in these institutions was below the average requirement. A study among Dutch hospital

patients showed that, in 2019, the protein intake among ~32% of older adults (aged 67 on average) who had been admitted for knee or hip surgery was below 0.6 g/kg of body weight.[136] It was also found that 41% of a group of elderly patients (aged 65 and over) were not achieving the recommended protein amount of 0.8 g/kg of body weight.[137] Protein and energy intakes were both too low in these studies. The low intakes in hospitals and rehabilitation centres can be explained by the fact that meals are not always consumed in full.[136,137] The DNFCS Older Adults 2010-2012 showed that elderly people who live at home (70+) and have disabilities that make them less mobile (defined as being unable to climb stairs) have energy, protein and calcium intakes that are lower on average than elderly people without these limitations.[121]

Based on the DNFCS of the general population, an inadequate protein intake (calculated on the basis of the healthy reference weight) occurs most in the group of people who are (extremely) underweight compared to people who have a healthy weight or are too heavy.[34] Slightly more than 10.3% of the group of men aged 18-59 who are (extremely) underweight have an intake below the average requirement; 8.3%-9.4% of women between the ages of 60 and 79 who are (extremely) underweight have an intake below the average requirement. Extra attention needs to be paid to protein quality for all the groups of people mentioned who do not consume enough protein (or energy). The same applies to the intake of nutrients that are points of attention for the general population as well.

Conclusion regarding people with low protein and energy intakes

For people with low protein and energy intakes (patients in hospitals, nursing homes and rehabilitation centres and elderly people with home care, for example), good protein quality in addition to the intake of total protein is extra important. In some cases, the protein requirement may be higher than for other adults. Besides protein and protein quality, attention must also be paid to the intake of other nutrients. With this in mind, the committee believes that extra attention to these groups will be necessary with regard to the protein transition. The committee sees an important role for dietitians here.

4.7 Summary and conclusions

The same nutritional points of attention apply to all the specific groups mentioned as those applicable to the general population. Although fewer data are available for some groups, the committee still concludes that the protein transition will also have health benefits for people with chronic diseases and obesity. This applies to children as well. However, the dietary reference values for children are less well substantiated and their nutritional needs can vary greatly depending on their growth rate. This makes it more difficult to assess their nutritional status. Given this fact, it is even more important to monitor the dietary intake and nutritional status (growth) of (young) children.

More attention and research are necessary for pregnant women, breastfeeding women and people with low protein and energy intakes (due to illness or vulnerable health, for example). Zinc will become extra important for pregnant and lactating women (see Table 2). The same applies to protein and protein quality, but actually all nutrients, for people with low protein and energy intakes. If people in these groups already want to consume a more plant-based diet, it will be important for them to have sufficient information and the guidance of a dietitian. To facilitate this, dietitians and others will need to be trained, or have extra training, to give specialist advice about plant-based nutrition. Additional training and guidance will also need to be given to catering facilities, especially those that cater for patients and the residents of health care institutions (hospitals, nursing homes and rehabilitation centres, for example) and vulnerable elderly people who live at home.

Table 2 Nutrients for attention in the protein transition for the general population and for specific groups within the general population

	Current intake[1]	Protein transition[2]
General population	Vitamin A Vitamin B2 Calcium Fish fatty acids	Vitamin B12
In addition to the above, the following applies for the groups below:		
Women	Iodine	
Women and girls of childbearing age	Iron	
Pregnant women	Iodine	Zinc[3]
Lactating women	Iodine	Zinc[3]
People with low protein and energy intakes	Protein Protein quality Dietary pattern and nutrients in general	

1 Based on the Dutch National Food Consumption Survey 2019-202134
2 These nutrients will become a point of attention with regard to the protein transition
3 Due to the higher zinc reference value in these groups and in the absence of intake and status data

05
the vegetarian diet

The committee states that adopting a vegetarian diet with fish included once a week is a practical way to achieve the 60% plant-based and 40% animal-based protein ratio in the Netherlands. In 2001, higher recommended amounts of proteins were advised for vegetarians and vegans to compensate for any lower protein quality.

Based on new calculations, the committee concludes that a higher dietary protein recommendation for vegetarians is no longer necessary. More research is needed into the protein dietary reference values for vegans, so the existing protein advice will continue to apply for the time being. However, extra attention is required for pregnant women, breastfeeding women, people with low protein and energy intakes and children who consume a vegetarian diet.

5.1 The vegetarian diet and health

A vegetarian diet (with fish included once a week) is one Dutch diet that comes close to the ratio of 60% plant-based to 40% animal-based.[34,138] People who consume a vegetarian diet already consume in accordance with the protein transition and, as such, can be informative for the rest of the population.

In research conducted by Western countries, a vegetarian diet is often also accompanied by a healthier lifestyle: vegetarians smoke less and are more physically active than omnivores.[61] Vegetarians also have a higher level of education on average.[34] Although these differences are not always found,[139] they can distort research results. Even so, the risk of chronic diseases is lower among vegetarians (see Chapter 3). Just a limited amount of research has been conducted into muscle and bone health in vegetarians. A fully plant-based diet may not be beneficial to bone health.[82] In particular, it may be more difficult for people with a vegan diet to get enough of all the nutrients that are mainly found in animal-based products. For example, the prevalence of a vitamin B12 deficiency generally increases in line with a decrease in animal-based foods.[98] This is why vegans have been advised to take a vitamin B12 supplement since 2009.[28,140]

Protein intake

Little information is available about nutrient intake and adequacy among Dutch vegetarians. For the purpose of this advisory report, the nutrient intakes of people with a vegetarian diet (with or without fish), including a few people with a vegan diet, have been compared with non-vegetarians based on the latest DNFCS.[34] Vegetarians were relatively often female, middle-aged and highly educated. A higher level of education was associated with better nutritional status among both non-meat eaters and meat eaters. To avoid any distortion of results, the comparison was therefore limited to women (aged 18-79) (n=70 of a total of 136 vegetarians).

Slightly more than 16% of women who consume a vegetarian diet have a protein intake below the average requirement if calculations are based on actual body weight, compared to 10.2% of women who consume a non-vegetarian diet. If calculations are based on the healthy reference weight, the percentages are below 10%. According to the DNFCS, more women have a protein intake below the average requirement than men and children do (see Chapter 3). Therefore, the committee expects that the percentages of vegetarian men and children with a protein intake below the average protein requirement will not be higher than the percentage for vegetarian women.

An analysis in the Lifelines study conducted among a larger group of people with a vegetarian diet (n=2390) confirms the influence of body weight on the estimates of the adequacy of protein intake (see the Life-lines background document). If calculations are based on actual body weight, the percentage of vegetarians (men and women) with an intake below the average requirement is 12.9%. If calculations are based on the healthy reference weight, this percentage decreases to 7.2%. Of the 160 people with a vegan diet in the Lifelines cohort, 22.2% (based on actual weight) and 14.5% (based on actual weight) have an intake below the average protein requirement.

The committee concludes that, on average, the current protein intake among vegetarians meets the requirement and that a vegetarian diet that includes fish once a week is one way in which a proportion of 60% plant-based and 40% animal-based protein could be achieved.

Protein values and protein quality

The amount of protein intake can compensate for a poorer protein quality. In 2001, this idea was the guiding principle when determining the increase in protein recommendations by a factor of 1.2 for people with a vegetarian diet.[40] In light of the protein transition to more plant-based protein sources for the entire population, these calculations have been revised and expanded to include more protein sources, especially plant-based protein sources and various combinations of these sources. In this advisory report, the committee has not revised the factor (of 1.3) for vegans.[40] Little is known about the current dietary intake of this group (which protein sources are consumed and in which combinations). For example, vegans are hardly represented at all in the DNFCS.

However, the committee believes that sufficient data are available about vegetarian diets to be able to re-evaluate the conversion factor.
The new calculations produced by the committee (see the Protein quality background document) show that the combination of two protein sources – one animal-based and one plant-based – in a protein ratio of 60:40 does not result in a protein quality of <100% (where 100 or higher is optimal) in any example situation. Adjusting the ratio to 40% animal-based and 60% plant-based proteins reduces the protein quality of all combinations of two

products. However, protein quality does remain above 90% in a large number of example combinations. If the number of sources is increased from two to three (one animal-based source and two plant-based sources), protein quality generally increases. A value between 95% and 100% is found for most example combinations. The committee notes that people with an omnivorous diet can fall below 100% as well. In the calculated scenarios, the lowest value was found for the following combination: red meat, potatoes and mushrooms (81%).

The protein quality calculations should be regarded as illustrative. Additional plant-based protein sources and/or different ratios in protein-source combinations may influence the results. Also, the expectation is that new data that make it possible to estimate protein quality better will become available in the next several years (according to the DIAAS method advised by experts).[41] Despite the methodological caveats, these theoretical calculations *do* indicate that the shift from 60:40 to 40:60 (animal-based:plant-based protein) will have implications for protein quality if protein intake remains the same. However, the present transition would appear to offer sufficient opportunities to achieve an omnivorous or vegetarian diet with good protein quality. In the event of further-reaching shifts, extra attention will need to be paid to the need for good combinations of foods and/or an increased protein intake.

The committee concludes that it is possible to consume sufficient proteins and have a protein intake of sufficient quality with a more plant-based diet. However, it will be important to combine protein sources. In practice, this can mean that sources like legumes are on the menu more often or in larger quantities. In the context of the combination of protein sources, the committee would like to mention developments in respect of (individual) advice on protein quality (on websites and apps, for example).
The committee is of the view that the higher dietary reference value for protein set for vegetarians in general is no longer useful or desirable from an environmental point of view. This is because the recommendation to consume more (protein) will be accompanied by a higher environmental impact.

Other nutrients

Based on the DNFCS, vitamin and mineral intake was estimated separately for vegetarian women (n=70) compared to non-vegetarian women.[34] The adequacy of vitamin A, vitamin B2 and calcium did not differ significantly between the groups. Although the average total iron intake did not differ between groups, vegetarian women (18%) were more likely to fall below the average iron requirement than non-vegetarian women were (~10%). Where zinc is concerned, the intake of more than 17% of vegetarian women was below the average zinc requirement, compared to the intake of 3.5% of non-vegetarian women. Vitamin B12 intake was below the average requirement for more than 30% of vegetarian women

compared to 10% of non-vegetarian women. These results do not include supplement intakes. The data are difficult to put into perspective, because the comparison is based on just a small group of vegetarian women.

A meat-free diet according to the Wheel of Five (with fish once a week), in which meat has been replaced by legumes, nuts and eggs, will not contain the full recommended daily amount of some nutrients for a number of target groups. However, the same applies even if meat *is* consumed.[97] Also, the recommended amount of zinc intake is not completely achieved for boys aged 1-13 and girls aged 1-8 who consume a meat-free diet (with fish) and the recommended vitamin B12 intake is not fully achieved for breastfeeding women.[97]

The committee concludes that it is important to improve the identification of the nutrient intake and status of people with a vegetarian diet across the population, because the former are represented to just a limited extent in the DNFCS. Extra attention is required for pregnant and lactating women, people with low protein and energy intakes and children who consume a vegetarian diet.

06
the environmental impact of the protein transition

Animal-based proteins have a bigger environmental impact than plant-based proteins do. It is estimated that the protein transition could lead to a reduction of approximately 25% in greenhouse gas emissions and land use compared to current diet. The committee concludes that other changes, such as the innovation of production systems and the reduction of food waste, will be necessary in addition to the protein transition to achieve the climate targets and stay within the planetary boundaries. The committee believes it is important that the environmental impact of protein sources and food continues to be monitored. Also, estimates are needed of the environmental gains that could be achieved in the Netherlands if overconsumption is avoided.

6.1 Scientific developments

Sustainability and the environmental impact of food systems are currently the subject of much attention in society, in Dutch and European governments,[10,23] the private sector and science.

Investments in scientific research in this field have generated relevant new knowledge. Research is also being conducted into more sustainable (alternative) protein sources, dietary patterns and food production methods, such as circular agriculture and the reduction of emissions. Many developments are expected in the years ahead. Alternative protein sources are defined as protein sources of both animal-based (insects or cultured meat) and plant-based origin (lupine or algae, for example) with a (potentially) lower environmental impact than conventional animal-based protein sources.[141-144] The environmental impact of cultured meat is difficult to estimate, because the cultivation and production processes are still at the development stage.[145]

6.1.1 Databases

The development of databases with data on the environmental impact of foods has played an important role in knowledge development (see the Life cycle assessment text box on the next page). Data on the environmental impact of foods across the entire life cycle, from production to consumption, are increasingly being added to databases. The number of environmental impact indicators in databases is increasing as well. This is relevant because the effects on different impact indicators can be different. For example: in organic agriculture, greenhouse gas emissions and the pressure on biodiversity are lower, but land use is actually higher than it is in conventional agriculture.[146,147] RIVM has used six environmental impact indicators to calculate the environmental impact of various foods that are highly consumed in the Netherlands (see the Database on the environmental impact of foods text box on the next page and Paragraph 6.2.3).

Life cycle assessment

A life cycle assessment (LCA) is commonly used to calculate the current environmental impact of food groups or products. It can be performed for a product or process and relates to every phase of the life cycle. The LCA of a food focuses on the production, processing, packaging, transport, sale, storage, preparation, consumption and waste phases. An LCA generates a quantitative estimate of various environmental indicators. This set of fixed data does not include data about the mutual coherence between environmental indicators. For example, changes in land use affect greenhouse gas emissions, but this is not included in the LCA.

The data in an LCA database are not direct measurement data, but composite data. They are based on life cycle inventory (LCI) data, which relate to all the relevant material and emission flows throughout the life cycle of a food. LCI data are sometimes direct measurement data, but often extrapolations or modelling of other measurement data.[148,149] Inventory databases include the Agri-footprint database developed by Blonk Consultants, the Agribalyse database developed by ADEME and the World Food LCA Database developed by Agroscope, Quantis and Ecoinvent.[150-153] A model is used to combine and translate these LCI data into environmental impact indicators in the LCA. International standards and European rules apply for both the LCI and the LCA methodologies.[154,155] The European Commission is currently developing a method to measure and communicate about the environmental impact of products and services.[156]

Database on the environmental impact of foods

RIVM has included LCA data of six environmental indicators for 250 foods in the database on the environmental impact of foods. RIVM uses the ReCiPe model to calculate these LCA data (from LCI databases).[157] The foods in question account for 75% of Dutch food consumption.[158] Extrapolations to other foods make it possible to estimate the environmental impact of the current Dutch diet on this basis.[157-159]

Greenhouse gas emissions: an indicator of global warming. Greenhouse gas emissions are expressed in kg CO_2 equivalents. This can be used to aggregate various greenhouse gases.

Water use: an indicator of freshwater use as a consequence of human activity. This is the irrigation water used when growing crops. It is also referred to as the 'blue water footprint'. Water use is expressed in m^3 of water.

Land use: an indicator of land area use. This includes the transformation of a certain land area to prepare it for production. Land use is expressed in m^2*year: used surface of land multiplied by the period of use.

Acidification of the soil: an indicator of the change in soil acidity as a result of the precipitation of reaction products of gases, such as sulphates, nitrates and phosphates, from the sky. These reaction products form acids. Acidification is expressed in kg SO_2 equivalents.

Eutrophication of saltwater and freshwater: the eutrophication rates of saltwater and freshwater are indicators of the enrichment of the saltwater and freshwater environment by nutrients. These consist primarily of nitrogen oxides and phosphate compounds from various sources. Eutrophication is expressed in kg N equivalents (salt water) and kg P equivalents (freshwater).

However, knowledge gaps do still exist. Some indicators are rarely included. This might be because of the absence of a standard measurement method for them at the current time. Therefore, biodiversity, overfishing, the use of antibiotics and chemical pollution are not usually included among outcome indicators.[160,161] The refinement of data in product groups is necessary as well. For this, data are necessary in which allowance is made for differences in production processes, production systems (conventional, organic or circular agriculture) and the location of production.[160,162]

As the Health Council pointed out back in 2011,[115,163] reporting on uncertainty is a matter for attention when seeking to identify the environmental impact of food. Uncertainties can be found in the measurement data themselves and in the mathematical models used[164] (see the Life cycle assessment text box). Calculating the environmental impact of a product often results in just a single data point. In practice, however, the outcome can sometimes be different for the same product depending on the production process, the cultivation method or transport. A data point may also change over time. Uncertainties are acknowledged, but are not usually quantified.[164,165] Comparisons of analyses with different data sources show that caution must be taken when interpreting data in absolute terms and when comparing studies with each other.[166,167] However, environmental impact data can be used to identify differences between product groups and to estimate the effects of consumption changes within the same study.[168] Therefore, the committee uses these data to estimate differences (between animal-based and plant-based products) in this advisory report. The committee believes it is important to have up-to-date data on the environmental impact of foods and to monitor changes in environmental impact over time. The committee also believes it is important for the origin of data on environmental impact to be more transparent. This transparency is necessary for both LCA calculations of environmental impact (LCA) and source data (LCI), to make it possible to assess data better, and to reduce uncertainties.

6.1.2 Models

Major investments are being made in the development of mathematical models of consumption patterns, production systems and sustainability indicators.[169-171] These models are being used to study complex relationships within the food system – between environmental and nutritional aspects, for example. These models can also be used to simulate the effects of future changes (in consumption, production or policy). Examples include models that focus on food consumption patterns, models based on production systems and models that cover the entire food system, including social and economic factors. Developments in this field are moving towards the integration of as many food system components as possible.[172] For the time being, various models are complementing each other.

Models that contain information about food consumption and environmental impact can be used to identify desired consumption patterns, like a diet that is nutritionally adequate and has a low environmental impact (also see Paragraph 6.2.2).[173] Models can be based on intake data about individuals or groups. Where environmental impact is concerned, these models use fixed (LCA) data to identify the environmental impact per food product. The same applies to the Optimeal and SHARP models.[86,87] LCA data can be used to indicate the environmental impact of the current diet and to estimate the environmental impact of relatively small changes.[174] Fixed LCA data are no longer suitable for the analysis of large changes in food consumption (across the population) or production, because this would require the food system to change in line with these changes and the LCA data would then change as a result. Models of the production system are needed in this situation.[174] They take account of the land available, the type of land suitable for which crop and any connection between the production chains (beef from slaughtered dairy cows and dairy, for example). Models like this generate results about the quantities of raw materials produced and possibly also about the corresponding nutrients and/or environmental impact that the production system has on a certain country or region. On a global scale, a model like this has been used to estimate the environmental impact of the system in the event of the expected increase in food demand in the coming decades.[175] The Circular Food System model (CiFoS) has been developed for the European context.[171]

A model for circular agriculture: CiFoS (Circular Food System)

The CiFoS model has been developed with a view to designing a sustainable European food system. The model contains information about every aspect of the production system, like land types (such as grassland), production data for animal-based and plant-based foods, fishing and waste flows. The model calculates combinations and quantities of products, nutrients supplied by the system and the environmental impact of various scenarios. Various requirements may be specified within scenarios. For example, the EFSA dietary reference values or quantities of foods can be entered as nutritional requirements and a maximum value can be specified for greenhouse gas emissions.

The model calculates the optimal combination of products within these boundaries. The environmental impact is calculated on the basis of formulas that have been developed in line with international standards.[171] The CiFoS model is able to apply circularity, which means that waste or by-products from a particular process are used elsewhere in the chain. Minimising the environmental impact avoids products being fed to animals when they are actually suitable for human consumption. Animal feed will consist largely of residual agricultural products and grassland. Other principles are that every edible part of livestock should be consumed (including offal) and that fertiliser use will be circular wherever possible. The latter will prevent over-fertilisation and ensure that compost will be used wherever possible.[171]

6.2 Environmental impact

6.2.1 Diets within the planetary boundaries

Estimates of the environmental impact of food systems are continuing to improve. The changes necessary can be determined by comparing food systems against certain limits (the climate targets or planetary boundaries, for example). The planetary boundaries indicate the environmental frameworks within which food production must stay to be able to continue to utilise the planet's resources and, as such, ensure that future generations have healthy food.[17] It is assumed that ecosystems become unstable if the planetary boundaries are exceeded.

Although predictions of future environmental pressure and estimates of the planetary boundaries are subject to some uncertainty,[175] a consistent picture is emerging from various analyses. Changes in consumption are necessary, but insufficient.[6,113,175] The environmental impact of production systems and food waste must be reduced as well (Figure 6).

As regards consumption, there are two important strategies for reducing the environmental impact of food in the Western context, which includes the Netherlands. The first is the prevention of overconsumption (consuming more energy than necessary) and the second is the shift to a more plant-based diet: the protein transition.[111,113,115] It is a known fact that overconsumption in general is an issue in Western countries like Europe and the consumption of meat and dairy is much higher than the global average in these countries.[166] A systematic review of international modelling studies into healthy diets with a lower environmental impact concluded that the environmental benefit can be explained in part by a reduction in total food consumption.[176]

What needs to be done to reduce the environmental impact of food?

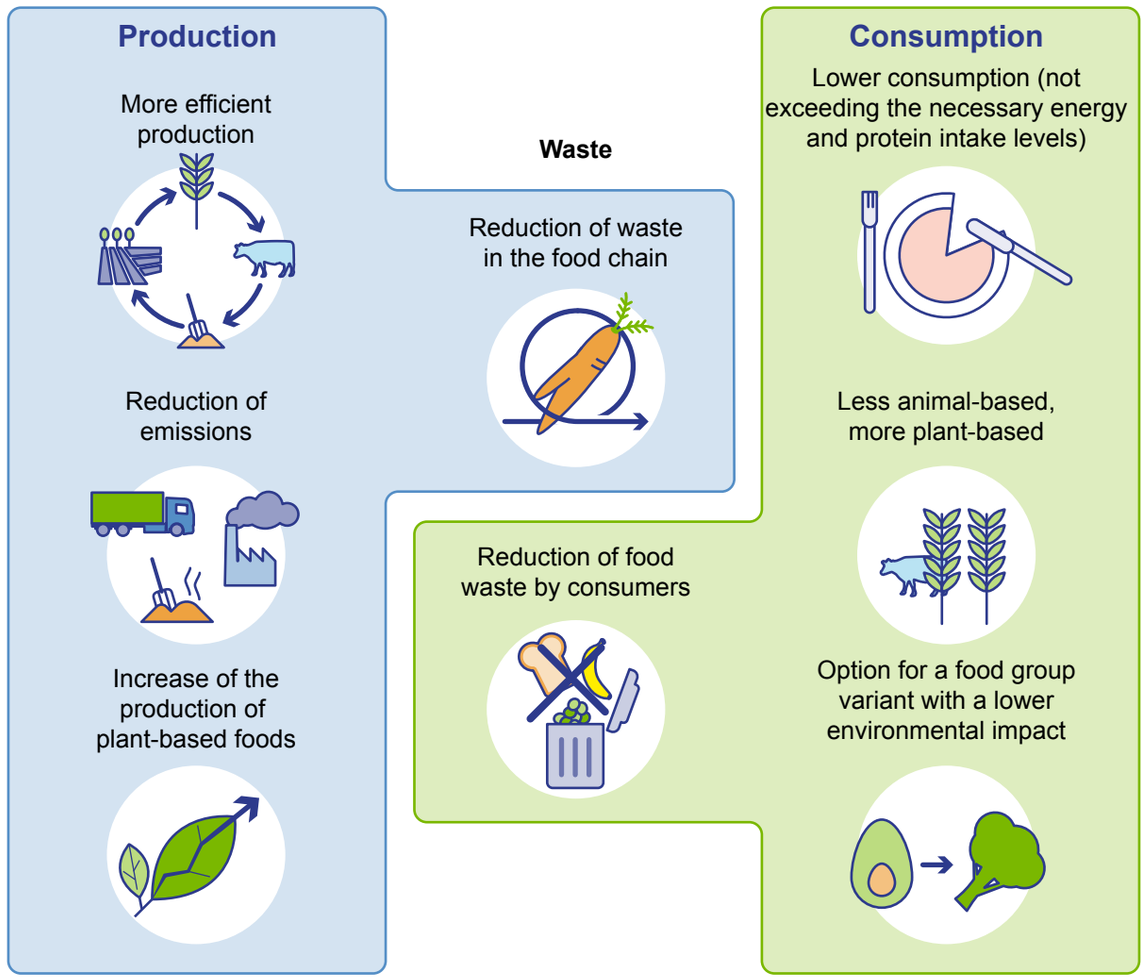


Figure 6 Production and consumption adjustments that reduce the environmental impact of food

Estimates have been produced with the planetary boundaries in mind as well: what will a diet look like if the planetary boundaries are taken into account? These estimates also assume that food production will become more efficient and that food waste will be reduced significantly.[6,113]
The impact of the EAT-Lancet diet remains within the planetary boundaries.[113] In this analysis, the total energy intake is approximately the same as the current intake. It is estimated that the consumption of red meat needs to decrease to a maximum of approximately one portion per week and that the consumption of nuts, vegetables, fruit and legumes in particular will increase sharply. Other estimates, based on the climate targets, are less extreme for meat and focus mainly on the population group that consumes the most red meat: the 20% of the population that consumes the most red meat should limit this by 40%.[6] If estimates are based on circular agriculture, the resulting diets will have different animal-based protein sources to those in the EAT-Lancet diet and the environmental impact will be lower.[177]

The World Wildlife Fund (WWF) has conducted a study to identify what a diet within the planetary boundaries would look like in the Dutch situation.[178] It used the Optimeal® model. Five planetary boundaries were included: greenhouse gas emissions, land use, nitrogen surplus, phosphate use and irrigation water use. Assumptions were made about future, more efficient production systems, the use of green energy and a decrease in food waste.

The modelled diet, which is within the planetary boundaries, contains far less meat (approximately one portion per week), less cheese and more vegetables and fruit, nuts, legumes, soy and meat substitutes than the current diet. The proportion of plant-based proteins is between 64% and 74% and the total amount of proteins decreases by 4%-7%. The authors conclude that a proportion of 60% plant-based proteins is just not enough to stay within the planetary boundaries, but that 80% or 100% plant-based protein is not necessary, provided the assumptions for more sustainable production are met. Compared to the current diet, this diet will result in a decrease in greenhouse gas emissions by 49%-83%. Land use, phosphate use, nitrogen surplus and biodiversity loss will decrease by 50%-80% and there would be a change in irrigation water use of +7% (among women) and -43% (among men).[178] When developing the diet, the researchers took feasibility into account. However, a diet within the planetary boundaries still represents a major change in terms of meat consumption.

The assumption in the WWF study is that the energy intake will stay the same as in the current diet. However, current food consumption is too high, with many people being overweight or obese. No estimates of the effect of overconsumption (alone) on environmental indicators have been found in Dutch studies. The committee observes that little attention has been given to this aspect as a way of reducing the environmental impact of our diet.[165] Therefore, it believes that data are necessary to facilitate the

separate quantification of the effects of consumption shifts and reductions. In the WWF study, assumptions were also made about production, which it was assumed would be more efficient, and food waste, which it was assumed would decrease. However, additional measures will be necessary if the food-waste-reduction goals are to be met.[179] This highlights the importance of changes in production, waste and consumption.

Previous Dutch studies, based on Optimeal® and a more limited set of environmental indicators, showed a similar picture.[1,104] The biggest change when shifting to a diet by which the climate targets are achieved (a 50% reduction of CO_2 equivalents in 2030 and 75% in 2050) involves consuming less meat and a smaller proportion of animal-based protein.[104] However, the authors have their doubts about the social acceptance of these diets and point to the need for innovations in food production.[104] Calculations by the PBL Netherlands Environmental Assessment Agency in 2019 showed that a 30%-40% reduction in greenhouse gas emissions and 25%-40% of land use could be achieved compared to the current diet (2010) by a combination of the following in particular: reduced meat or animal-based protein consumption, reduced food waste and more efficient and careful production.[1,] Hence, the available evidence shows that a combination of changes inconsumption, less food waste and a more efficient food production is needed.[1,104,178]

6.2.2 Environmental gains of the protein transition

In sum, the complete or partial replacement of animal-based protein sources by plant-based protein sources in the diet can make an important contribution to a reduction in the environmental impact of our current diet. The effect of such diets (vegetarian diets – which include the vegan diet – and diets with little meat) has been studied in various systematic reviews of international studies.[165,180-182] Due to the major methodological differences between the studies, the estimated effects vary widely. The decrease in environmental impact would appear to be more or less proportionate to the decrease in the amount of meat in the diet, with a (median) decrease of between 20%-30% in greenhouse gas emissions and land and water use.[181] In diets with a high level of red meat (beef, for example), the replacement of red meat with pork and white meat (chicken, for example) will yield environmental gains (a 20%-30% reduction in greenhouse gas emissions compared to the emissions generated by the existing diet).[165] Besides this, meat and dairy substitutes could also play a role in reducing the environmental impact of the diet. A modelling study among a number of European countries showed that replacing 75% of meat in current diets with meat substitutes could reduce greenhouse gas emissions from food consumption by up to one-third.[112]

The environmental impact of the Dutch diet is caused mainly by animal-based products.[158] The consumption of these products is the biggest contributor to greenhouse gas emissions, land use, acidification and

eutrophication (freshwater and saltwater). This applies mainly to meat, dairy and cheese, and to a lesser extent to fish and eggs. The impact of fish is limited, because consumption levels are relatively low. Plant-based products (not protein sources, but mainly fruit, fruit and vegetable juices, coffee and tea) are the biggest contributors to water use in the current diet.

Dutch studies in which substitution models were used (to study the effect of replacing foods) estimated that reducing animal-based product groups in the diet or replacing them with plant-based alternatives would result in a reduced environmental impact (see the Modelling studies background document).[85,94,183,184] A partial replacement of animal-based products (reducing meat and dairy consumption by 30% or halving meat consumption and moderately reducing dairy consumption) would reduce both greenhouse gas emissions and land use by approximately 15% compared to the current diet.[85,183,184] Replacing meat and dairy with plant-based products completely would reduce greenhouse gas emissions by 47% and land use by 41%-50%.[85,184] A modelling study among older people in the Netherlands showed that a healthy diet (according to the *Dutch dietary guidelines* and the dietary reference values) with an increased protein content (1.2 g/kg of body weight) was associated with a 50% reduction in greenhouse gas emissions (and 30% in land use) and a smaller shift in the consumption of animal-based protein in this group (from 55% to 50%). This group consumed a relatively high amount of red meat, all of which was replaced in the study by poultry (like chicken) and, to a lesser extent, pork. The percentage of plant-based protein sources was increased.[185] This shows that if a high level of red and processed meat is consumed, environmental gains can still be achieved by replacing the red meat with white meat.

Two studies have been conducted into the effect of the shift to a diet with a ratio of 40% animal-based and 60% plant-based protein sources on the environmental impact in the Netherlands. The PBL Netherlands Environmental Assessment Agency has studied this effect. For the purpose of this advisory report, the SHARP model has been used to estimate this effect as well[1] (see the SHARP background document). The two studies revealed similar results. A shift to a diet with 60% plant-based protein is estimated to result in a 25% reduction in both greenhouse gas emissions and land use compared with the current diet. However, the actual reduction in greenhouse gas emissions could be higher, because different land use also affects emissions in different ways.[186] This was not taken into account in these studies. The SHARP optimisation model focused solely on greenhouse gas emissions, which were reduced by 22%-24%. Both studies show that the shift results in a decrease in total protein intake by 11%-13%. This decrease means that the amount of proteins in food will decrease if more plant-based protein sources are consumed when total consumed energy remains the same. Besides a reduction in emissions, another object of the SHARP optimisation model

was to try to identify a diet that was in line with the *Dutch dietary guidelines 2015* (see the Modelling studies and SHARP background documents).

6.2.3 The environmental impact of protein sources

The consumption of animal-based foods contributes more to greenhouse gas emissions, land use and – indirectly – to the loss of biodiversity than the consumption of plant-based foods.[1,7,187] The differences in environmental impact between animal-based and plant-based protein sources are a result of the inefficient conversion of plant-based proteins into animal-based proteins.[166,188] It is estimated that the production of one kilogram of animal-based protein requires an average of six kilograms of plant-based protein. This includes three kilograms of plant-based protein that is edible for humans.[189,190] Figure 7 (on page 66) shows the environmental impact of a number of protein-rich foods on various indicators. The data were obtained from the database on the environmental impact of foods (in Dutch: Database Milieubelasting Voedingsmiddelen[157]), which is based on fixed LCA data per food item. The data do not take into consideration the coherence within production systems (such as chicken and eggs, and meat and milk from dairy cows). They do show that, per kilogram of product, animal-based protein sources in particular contribute more strongly to greenhouse gas emissions and land use compared to plant-based protein sources (see Figure 7).
The same applies to the effect on soil acidification and the eutrophication of salt water (not shown in Figure 7).[157] However, there are significant differences between animal-based protein sources: beef from beef cattle has a greater impact than pork, which has a greater impact than chicken, eggs and fish. However, compared to other animal-based protein sources, relatively little is known yet about the environmental impact of fish and seafood.[191] Current estimates show that there is a big difference in impact between different fish species.

Plant-based and animal-based sources would seem to require approximately the same level of irrigation water use, with the exception of cashew nuts and other nuts that involve high irrigation water use.[157]
The committee notes that this only applies to irrigation water. A systematic study shows that the total water use (including rainwater) of animal-based protein sources is actually higher than that of plant-based protein sources.[192]

Other indicators also show that nuts have the highest environmental impact of all plant-based protein sources (compared with legumes, bread, pasta and rice). A direct comparison, expressed per kg of product, between the environmental impact of moisture-rich products (milk, yoghurt, soy milk and potatoes) and that of the other product groups is not possible. The environmental impact expressed per kg of protein would be more relevant in this respect. Expressed per kilogram of protein, the environmental impact of plant-based products is closer to that of animal-

based products, because plant-based products contain relatively fewer proteins. However, they still have less of an impact than animal-based products do. The database does not contain any data about variations in estimates of environmental impact within product groups. A comparison of products globally shows that these variations can be considerable. However, animal-based products still have a higher environmental impact than plant-based products do.[2]

With regard to animal-based products, the primary production process (including feed and, where cattle are concerned, methane emissions) has the greatest impact on the environment. For plant-based products, this also includes cultivation, but processing, packaging, transport, storage and preparation phases contribute more in relative terms.[193] Meat and dairy substitutes are made from plant-based ingredients like soy (see the Meat and dairy substitutes background document). As a result, these substitutes have a lower environmental impact than animal-based protein sources (see Figure 7). However, more energy is sometimes needed to process ingredients and for any further production process.
Depending on the type of product, much of the environmental impact of meat and dairy substitutes, or the majority of it, is determined by the production process.[194] This makes it important to reduce the emissions that production systems generate.

6.2.4 Circular agriculture

The calculations referred to above in this advisory report assume changes in food consumption within current food and food production systems. Food system models can also model the effects of bigger changes, such as the shift to circular agriculture.[7] The Science Advice for Policy by European Academies (SAPEA) project of the Scientific Advice Mechanism of the European Commission considers the design of a food system like this a promising one for a future-proof system.[195] In circular agriculture, nutrients are used as efficient as possible. This means that animals are only fed the residual flows from food production that are not suitable for human consumption. It also means that cows only graze on land that is not suitable for the production of food for humans. As a result, a certain proportion of animal-based products is part of circular agriculture.[7,196] However, the level of these products will be lower than currently consumed and lower than recommended in current dietary guidelines.[197] A circular system would therefore also require changes in food consumption.

Recent analyses based on the CiFoS European food system model (preprint Nature Food) show that greater environmental improvements can indeed be achieved when the amount of protein shifts from 60:40 (animal-based:plant-based) to 40:60 within circular agriculture than within the current system.[198] If the current intake of the total amount of protein as well as the ratio of 60% animal-based and 40% plant-based protein are

being maintained, the optimised diet based on circular agriculture will contain far less red meat, but also less eggs and dairy and more fish, chicken and grains. Circular agriculture combined with a shift to a healthier diet can therefore generate significant environmental gains. When the objective of the model was to produce a food system in which both land use and greenhouse gases remained within the planetary boundaries, the total protein intake had to be reduced from the current intake (an average of 80 grams) to the average requirement (46 grams per person per day). The optimal percentage of animal-based protein was still 40%, but the total consumption of animal-based protein dropped to 18 grams per person per day.[198] This is well below current Dutch consumption levels of animal-based proteins (48 grams for adults).[34,198]

Animal-based protein sources generally have a higher environmental impact than plant-based protein sources

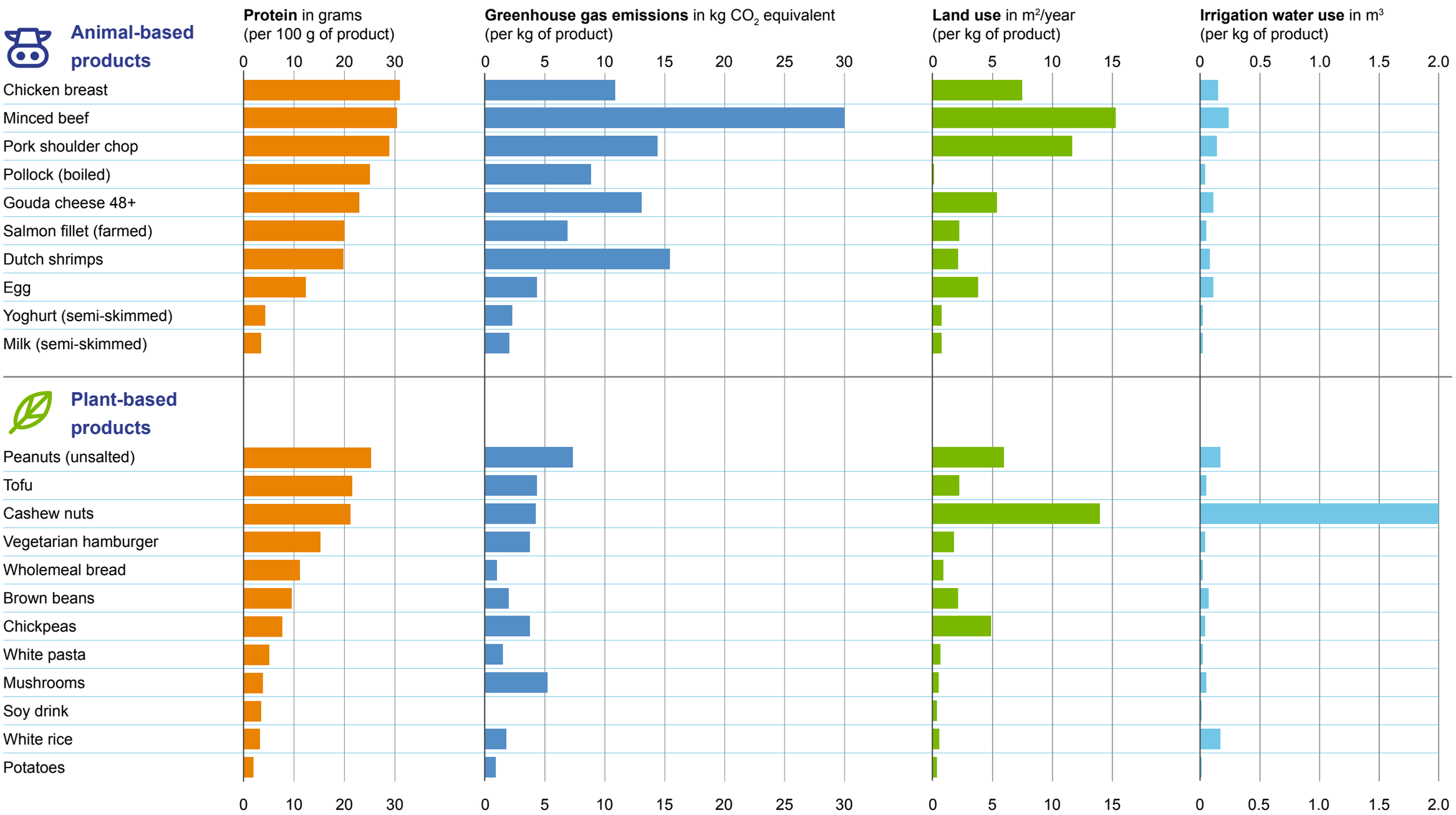


Figure 7 The impact of various animal-based and plant-based protein sources on greenhouse gas emissions and land use (per kg of product)[157]

07
policy perspectives

Successful implementation of the protein transition will require a comprehensive approach that goes beyond the responsibility of the individual consumer. A comprehensive approach includes creating a social, physical, economic and political food environment in which healthy and sustainable food becomes the norm. Amongst other things, this will involve making the available food healthier and more sustainable and improving food skills. Every party in the food chain, from producers to government, will have a role to play. The committee believes that knowledge about behavioural change will be an important building block for future policy and policy advice. This is why the committee also believes it is important to stimulate research into effective policy interventions with a focus on the food environment and behavioural change.

7.1 A comprehensive approach

In this advisory report, the committee sets out a number of key points that present opportunities for policy in the short term. It does this on the basis of recent systematic reviews and research that is relevant to the Dutch context. However, the committee also observes that further research into the social, physical, economic and political food environment will be important for the development of future policy.

The proportion of plant-based proteins in the Dutch diet is increasing, while the proportion of animal-based proteins is decreasing (see Chapter 2). A big proportion of the population would appear to be willing to consume less meat.[199] Nevertheless, the committee observes that an acceleration of the protein transition will be necessary to achieve a shift from the current proportion of 43% plant-based protein to a proportion of 50% in 2030, which is the current policy goal. An accelerated transition will become even more important if a further shift to a 60% proportion of plant-based protein is necessary.

The protein transition will require a change in behaviour from a large part of the population. However, behavioural change is not easy to achieve. Current food policy focuses very much on information provision (by the Netherlands Nutrition Centre) and, more recently, on ‘nudging’ (changes in the environment that subconsciously steer behaviour).[200] In this context, the government largely views consumption as an individual choice. This places a great deal of responsibility on the individual consumer and is insufficient as an approach for changing behaviour. Food consumption is the result of interactions between all kinds of factors at different levels (social groups, the physical food environment and at macro level (political and economic)) (see Figure 8 on the next page).[201-203] The protein transition will only become possible and feasible for consumers if changes are achieved at all these levels.[200,202,204-206]

Dietary behaviour is the result of various environmental influences

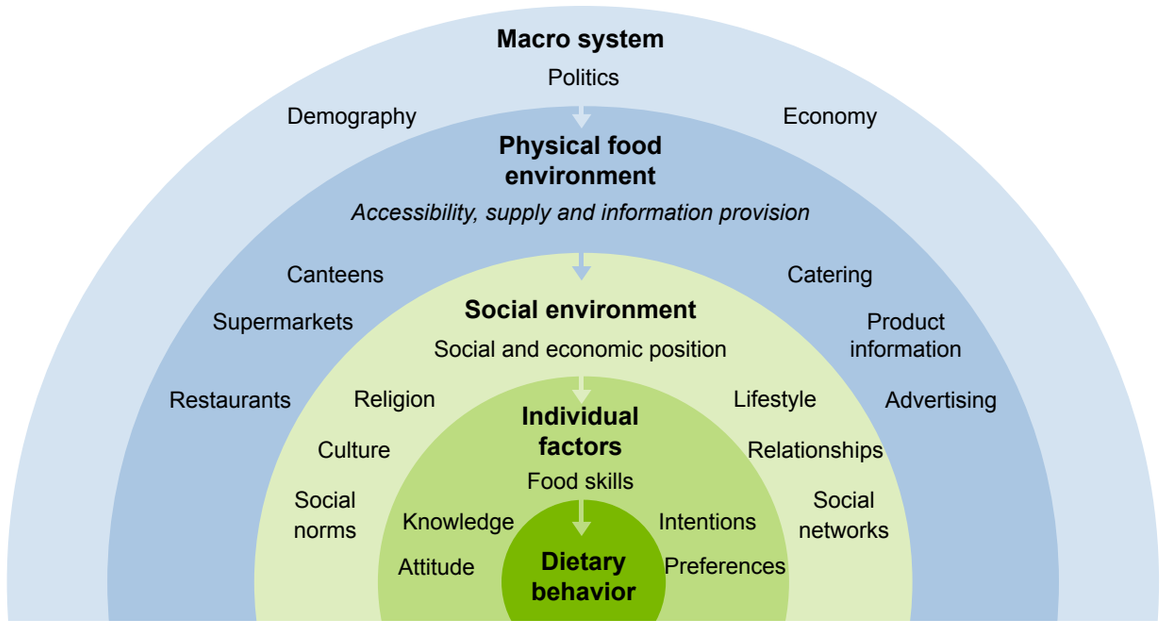


Figure 8 Multiple levels of effects on dietary behaviour

7.1.1 Individual factors

At an individual level, knowledge, attitude, intentions, food skills and preferences play a role.[202,205] Providing information about healthy, sustainable and safe food is one of the remits of the Netherlands Nutrition Centre. It identifies diets, daily menus and meals that comply with both the dietary guidelines and the dietary reference values of the Health Council of the Netherlands and are as close as possible to current diets for different population groups in the Netherlands. Improving people's knowledge about the environmental and health impact of food consumption is necessary, but will be insufficient to change behaviour.[202,207]

Many people do not know how to prepare healthy, tasty meals.[208,209] A lack of food skills (which includes the ability to put together and prepare a meal and use recipes) can be a barrier for people changing their consumption patterns.[202] The importance of food skills is often under-estimated.[202] Research aimed at improving food skills among groups with a lower socio-economic status is having limited, but positive effects.[210] More research is needed into the effects on dietary intake in the longer term.[210]

7.1.2 The social environment

Factors in the social environment (culture and religion, relationships, social networks, lifestyle and socio-economic position) play an important role in dietary behaviour. This happens in part through the formation of social norms surrounding nutrition.[200,202,205,211] Social norms are defined as the shared beliefs about which behaviours are right and proper in a given group. For example, meat is regarded as an important part of a meal in most Western countries.[212] It is especially seen as appropriate on special occasions.[213] Social norms can change, but little research has been done at this stage into which interventions are effective. However, it is clear that changing norms will require changes in a number of areas in society.[214] This includes operationalising scientific knowledge about the benefits of a

more plant-based diet – in dietary guidelines, for example. The availability of food in the physical environment has a role to play as well.[211,214]
The polarisation of views on animal-based and plant-based food is hindering social acceptance of the protein transition in society.[214]

7.1.3 The physical food environment

The physical food environment is defined as the environment in which food choices are made.[215] It is formed by the place where food is available (at home, at work, in the supermarket, in restaurants and via the catering provided by hospitals and health care institutions, for example) and by its accessibility, the composition of food and the way in which the available food is presented (see Figure 8). It is also the place where information is provided about food (both on product labels and as digital information) and food is advertised.[202,215-217] Although a relatively large amount of research has been done on the effects of the food available at point-of-sale level on purchasing behaviour – close to home, in shopping centres and around schools, for example – results vary and are difficult to interpret.[215,218] The committee believes that more research needs to be done at the level of the physical food environment to gain a better idea of the potential of the various food environments to achieve a healthy and sustainable diet. Below, the committee looks at two specific aspects of the food environment that it considers important in the context of the protein transition and for which more consistent data are available: the availability of food (in restaurants, catering facilities and supermarkets) and the nutritional composition of ready-made plant-based meat and dairy substitutes (mainly in supermarkets).

Food availability

In supermarkets, an increase in the visibility of plant-based products and a reduction in the portion size of pre-packed meat are leading to a decrease in the total amount of meat being bought and consumed.[219] It has also proved to be possible to get consumers to consume more plant-based and/or less animal-based food in places where meals are served (in restaurants, canteens and catering facilities).[216,219,220] A change to a smaller portion of animal-based food and a bigger portion of plant-based food would seem to be very acceptable to consumers as well.
Some restaurants and catering facilities are already making changes to the range of meals they supply. Catering facilities that provide meals in health care institutions (hospitals, care homes and rehabilitation centres) or to elderly people who live at home have to take into account the nutritional needs of the patients or residents in question. A need may be met here by offering training programmes for catering facilities in health care institutions.

Nutritional composition of ready-made meat and dairy alternatives

The nutritional quality and positioning of ready-made meat and dairy alternatives are an important matter for attention for the committee.
The nutritional composition of these alternatives varies to a large extent

(see the Meat and dairy alternatives background document).
The committee is of the view that the currently available ready-made meat and dairy alternatives can have nutritional advantages and disadvantages compared to meat and dairy. They usually contain less saturated fat and more fibre, but usually also less protein and more added salt or sugar. Far from all alternatives are fortified with vitamins and minerals (iron, calcium, vitamin B2 and vitamin B12) and, if they are, the level of fortification varies. For the benefit of consumers who regularly use these alternatives, the committee emphasises the importance of ensuring that such products provide essential nutrients in quantities comparable to the products they replace. The committee also believes it is important for the levels of added salt and sugar in these alternatives to improve. There are no regulations on when ready-made substitutes for meat, dairy, or fish can be regarded as such. The Netherlands Nutrition Centre has developed criteria to determine whether ready-made meat and dairy substitutes can be included in the Wheel of Five.[97] The committee endorses the previous recommendation of the Health Council of the Netherlands, namely to develop international criteria on the nutritional composition of meat and dairy substitutes.[107]

7.1.4 The economic and political environment

Economic and political choices in the macro environment affect the price of products. Price plays an important role in the food choices that consumers make,[203] particularly in countries with low incomes and in households with the lowest incomes.[32,33,221,222] Cost considerations also play a role when deciding whether or not to consume more plant-based protein sources.[223] Little information is available about the price of sustainable diets at the current time. The limited information that *is* available shows that the price of food with a lower environmental impact is comparable to the price of the food currently being consumed.[224,225]

The committee has estimated the cost of shifting from a diet with 60% animal-based and 40% plant-based proteins to a diet with 40% animal-based and 60% plant-based proteins. Its calculations show that, on average, the shift to a 40% animal-based and 60% plant-based diet, including a 10% reduction in total protein (with keeping energy intake constant), will not have a big effect on price (see the The cost of the protein transition for consumers background document). Naturally, certain choices make a plant-based diet cheaper or more expensive.
For example, meat is relatively expensive and replacing it with legumes will be cheaper than replacing it with nuts.

It is known that changes in the price of meat, dairy and fish have a relatively big impact on the decision whether or not to buy it.[222,226]
Research is currently being conducted into financing models like ‘true pricing’, in which external effects (the unintended side effects of food production or consumption) on the environmental, social and health costs of food production are passed on in the price.[227,228]

7.2 The food system transition

The protein transition is part of a bigger transition to a more sustainable food system. Transitions, or system changes like those in the food system, only get going if they are implemented in multiple parts of society.[229] Innovation is necessary and changes must be encouraged in political and economic environments.[229] The food system is a complex entity and involves a large number of parties with diverse interests, but all these parties have a role to play in the success of the protein transition.[204,206] This involves parties that make food available (producers, processors, distributors, food suppliers, supermarkets, catering facilities and restaurants) as well as the parties that play an informative role (knowledge institutions, social organisations and influencers).[204,206]

A transition to a more sustainable and healthier food system will only be possible if all the parties concerned take responsibility. The government will need to take control in this regard.

08 advice

8.1 Answers to the request for advice

The committee concludes that the protein transition will benefit the health of most of the Dutch population and reduce the risk of chronic diseases. The new diet will comply even better with the *Dutch dietary guidelines* than the current Dutch diet does. Therefore, the committee recommends implementing policy measures targeting the entire population to achieve the current policy goals (a ratio of 50% animal-based and 50% plant-based proteins in 2030) and subsequently promote a further shift to 40% animal-based and 60% plant-based proteins.

An important advantage of the protein transition is that the consumption of a healthy (more) plant-based diet with whole grains, fruit, vegetables, nuts and legumes lowers the risk of cardiovascular disease, type2 diabetes and cancer. Reducing the consumption of red and processed meat is also associated with a lower risk of disease. Furthermore, the protein transition will lead to a decrease in the intake of saturated fats and possibly salt, while increasing the dietary fibre intake. It is possible to implement the protein transition in such a way that the intake of nutrients like protein, calcium, iron and vitamins remains adequate. The committee expects no detriment to muscle and bone health for the general population due to the protein transition.

Pregnant women, breastfeeding women and people with low protein and energy intakes (due to illness or vulnerable health) require more attention. People from these groups who choose to consume a predominantly plant-based diet should do so well-informed, for example with guidance from a dietitian.

A vegetarian diet with fish included once a week is one way to implement the protein transition. Based on new calculations, the committee advises abolishing the higher protein dietary reference value for vegetarians. However, it is important to combine protein sources carefully when consuming a vegetarian diet. The higher protein value for vegans will continue to apply for the time being due to a lack of data on intake and protein quality. The committee advises generating these data and then reviewing the protein dietary reference value for vegans.

The committee is of the view that the protein transition is part of a bigger change in the food system. This bigger change is necessary to reduce the environmental impact of the food system and continue to meet global food supply needs. The protein transition will make an important contribution to the reduction of the environmental impact of food consumption.
This environmental impact could be reduced further by making different choices within product groups. To achieve climate goals and stay within the planetary boundaries, the protein transition will need to be accompanied by action to avoid overconsumption, reduce environmental impact through innovation in production systems and combat food waste.

To make the protein transition feasible for consumers, the committee advises a comprehensive approach that targets multiple levels of society. In other words, efforts must focus on creating an environment in which healthy and sustainable consumption is encouraged. To achieve this, all the parties in the food chain must take responsibility and the government must take control.

8.2 Recommendations on the protein transition

The committee recommends monitoring the progress and health effects of the protein transition through the RIVM DNFCS and nutritional status studies and doing this in a more diverse range of population groups (vegetarians, people in the Caribbean Netherlands, groups with a migration background, pregnant women, breastfeeding women, children and the oldest seniors).

For the purpose of the protein transition, the committee also advises that steps be taken to train and educate dietitians and catering facilities and to provide information about nutrition, including attention to various diets and eating cultures.

Furthermore, the committee advises stimulating research into:

- the bioavailability of nutrients in plant-based diets in order to derive dietary reference values;
- the health effects of ready-made meat, fish and dairy alternatives, as well as alternative protein sources;
- the environmental effects of animal-based, plant-based and alternative protein sources (and their development), with attention for transparency of data;
- the potential environmental gains from avoiding overconsumption;
- the effects of interventions (including policy measures) that target the social, physical, political and economic environment in order to facilitate changes in food consumption.

The committee has not evaluated the health or sustainability effects of a vegan diet in this advisory report, because it was not asked to do so in the request for advice. However, the committee has observed a growing trend towards vegan diets, also in growing children and pregnant women. Individuals will only be able to ensure that a vegan diet meets all their nutritional needs if they possess the necessary nutritional knowledge or receive guidance in this respect. Insufficient data are currently available about the nutrient intake and status of people with a vegan diet. Therefore, the committee advises that research be conducted to gather more data about the vegan diet across the population.

8.3 Future dietary guidelines

The Minister and State Secretary have asked for an outline of an approach to the integration of health and sustainability that could be used in future dietary guidelines (*Dutch dietary guidelines*).[51]

In a joint meeting with the Nutrition committee, the Protein Transition Committee discussed ways to achieve the integration required. It also obtained information from abroad (see the text box on European developments in respect of nutritional recommendations). The Nutrition Committee will continue its development of the *Dutch dietary guidelines* on the basis of this information and any other recent developments.

When preparing the current advisory report, the Protein Transition Committee concluded that there is an increasing availability of data, of an increasingly better quality, on the environmental impact of food.
This increases the possibilities to compare the impact of different product groups. The committee has identified a number of aspects that require further elaboration in guidelines in order to reduce the environmental impact of food.

In the interests of both health and the environment, the extent to which scientific substantiation is available for the following must be ascertained when developing future guidelines:

1. The quantification of product group-specific guidelines.
   Recommendations for meat and dairy have not been quantified in the current *Dutch dietary guidelines* because of the insufficient basis provided for this by their health effects. Guidelines for many plant-based products have been quantified on the basis of their health effects. The Protein Transition Committee advises including information about the environmental impact of food when considering the quantification of guidelines.
2. The expansion of product choice recommendations within product groups (types of meat, fish or nuts, for example). Doing this would make it possible to include environmental impact information in these recommendations.

European developments in respect of nutritional recommendations

In June 2023, the Nordic countries published new dietary reference values and guidelines.[230] The health effects, health risks and environmental impact of each food group were assessedand presented. As a result, the recommendations exist within a certain bandwidth.

These recommendations will be developed further, per country, into more specific recommendations (food-based dietary guidelines) in which each country will be able to choose its own focal points.

The new German dietary guidelines are expected at the end of 2023. They are being developed on the basis of an optimisation model into which health effects and environmental impact have been integrated. The model will include prerequisites for health (dietary reference values, for example) and the gains to be achieved in terms of environmental impact.

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Committee and consulted experts[a]

Members of the temporary Committee on Protein transition for the advisory report

A healthy protein transition

- Prof. M. Visser, professor of Healthy Ageing, Vrije Universiteit Amsterdam, *chair*
- Prof. I.A. Brouwer, professor of Nutrition for Healthy Living, Vrije Universiteit Amsterdam
- Prof. C.P.G.M. de Groot, professor of Nutrition and Ageing, Wageningen University & Research
- Dr J.A.E. Langius, dietitian, associate professor/team leader of Nutrition and Dietetics, The Hague University of Applied Sciences, The Hague
- Prof. G.J. Navis, professor of Nutrition in Medicine and Experimental Nephrology, UMC Groningen
- Prof. E.W.M.L. de Vet, dean of University College Tilburg, professor at Tilburg University
- Prof. L.J.C. van Loon, professor of Physiology of Exercise and Nutrition, Maastricht University, *structurally consulted expert since July 2023*
- Dr E.H.M. Temme, research scientist at the National Institute for Public Health and the Environment and Wageningen University & Research, *structurally consulted expert*
- Prof. P. van 't Veer, professor of Nutrition, Public Health and Sustainability, Wageningen University & Research, *structurally consulted expert*
- Prof. H.H.E. van Zanten, associate professor, Farming Systems Ecology group, Wageningen University & Research, *structurally consulted expert*

Experts consulted in a private comment round on the draft advisory report

- Dr C. van Dooren, senior adviser on sustainable diets, World Wildlife Fund, Zeist
- H.J. Westhoek MSc, senior researcher on food and agriculture systems, PBL Netherlands Environmental Assessment Agency, The Hague
- Dr C.T.M. van Rossum, senior nutritionist, National Institute for Public Health and the Environment, Bilthoven
- Dr N. van der Wielen, assistant professor and researcher, Wageningen University & Research - also consulted occasionally in respect of the background document about protein quality
- Dr J.D. Mackenbach-van Es, assistant professor of Epidemiology and Data Research, Amsterdam UMC - also consulted occasionally in respect of the background document about costs

Observers

- Dr E.J. Brink, Netherlands Nutrition Centre, The Hague (until September 2022)
- C.L.E. van Houte, Ministry of Health, Welfare and Sport, The Hague
- J. Lok, Ministry of Agriculture, Nature and Food Quality, The Hague (as of September 2022)
- E.M. van Nes, Ministry of Agriculture, Nature and Food Quality, The Hague (until September 2022)
- Dr M. Seves, Netherlands Nutrition Centre, The Hague (as of September 2022)

Secretaries

- Dr M.J. Alssema, Health Council of the Netherlands, The Hague
- Dr J. de Goede, Health Council of the Netherlands, The Hague
- Dr K.G. van der Mark-Reeuwijk, Health Council of the Netherlands, The Hague

[a] Consulted experts are consulted by the committee because of their expertise. Consulted experts and observers are entitled to speak during the meeting. They do not have any voting rights and do not bear any responsibility for the content of the committee's advisory report.

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