Innovation pathways towards more sustainable production and consumption in the fruit-vegetable supply chain and their uptake in the SUSFANS models

Deliverable No. 5.3

SUSFANS DELIVERABLES

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Teaser for social media

In order to support and stimulate healthy and sustainable consumption in Europe, the intake of fruit and vegetable should be increased and brought more in accordance with recommendations. This will require a stronger consumer orientation of the current practices and innovation in fruit and vegetable supply chains. Innovation pathways could be rooted in the combination of a wide array of variables related to the individual (biological, demographics, psychological), the product, the interpersonal, while taking into consideration the physical environment and policy needs as well as societal drivers. The options for consumption-related innovations include: targeting, motivating, contextual, communicating and acceptance of innovations; product related innovations such as: product, production, package; and circular innovations.

Abstract

Fruit and vegetable consumption is below recommended levels and should increase to come closer to a more healthy and sustainable diet in Europe. The aim of this report is to identify innovation pathways in the fruit and vegetable chain from a consumer perspective.

The deliverable shows the different elements of a consumer perspective, their relevance and above all the need to combine consumer, production and circular perspectives on innovation to support fruit and vegetables consumption.

To understand or even stimulate consumption behaviour a wide array of drivers need to be taken into consideration, which relate to the individual (biological, demographics, psychological), the product, the interpersonal, physical environment and policy. These are represented in consumption-related innovations such as: targeting, motivating, contextual, communicating and acceptance of innovations; product related innovation such as: product, production, and package; and circular innovations (in particular around reducing food waste).

This paper is meant to inspire, raise awareness, and continue the discussion on a strengthened consumer perspective in the innovation strategies, foresight and modelling work in SUSFANS.

Background

This deliverable 5.3 describes the case of fruit and vegetable consumption from a consumer perspective and identifies possible innovation pathways towards more sustainable consumption patterns.

Current practices in the food system are problematic in terms of sustainability and nutritional security (Zurek et al. 2016). Therefore innovation and supporting policy are needed to achieve better system outcomes. The overall aim of SUSFANS is to assess in which direction the EU food system can move, while accounting for the trends that we see on the basis of improved metrics on the drivers and outcomes of the food system, enhanced modelling and foresight (Rutten et al., 2016). To achieve this, the current (baseline) situation and trends focussing on the two main areas diets and environment are explored. Livestock/seafood and fruit & vegetables were considered the two most pressing policy concerns and therefore in WP 5 two case studies were focussed on these topics.

The aim of work package 5 is to define different pathways towards more sustainable and healthy diets within the EU for the cases of livestock/seafood and fruit & vegetables. In the two case studies, the current situation and innovation pathways are described. In deliverable 5.1 the case studies are introduced (van Zanten et al. 2017b). One case study explores 'livestock and fish' focussing mainly on production (described in 5.2, van Zanten et al. 2017a); a study on 'fruit and vegetables' is focused mainly on consumption innovations and is described in the current deliverable . The innovation literature teaches us that there is always a behavioural component around changes in practices and technologies. Those changes must therefore be understood in a wider context. Specific innovations are always part of a societal and cultural (and economic and policy) change, as will be revealed for the various innovation options discussed.

In this paper the effort is made to embed the innovation options into a long-term perspective on the European food system. Production, consumption and the structure of the EU food system is expected to feature shifts under the influence of changes in the environment, culture, technologies –by a range of indirect and direct drivers in fact (Zurek et al. 2017; Havlík et al. 2018). This report will anticipate such a foresight perspective by proposing bundles of innovation strategies and options as *innovation pathways*. In D5.1 tentative innovation pathways are described and how the conceptual framework and metric (developed in WP1) can be used to determine whether or not the policy

goals are realized. The case studies 5.2 and 5.3 further build upon this 'proof of principle' by describing possible innovation pathways in more detail.

More specifically, the aim of task 5.3 is to operationalize innovation pathways in fruit-vegetable supply chains. As described in the DoA we will "*Identify and parameterize innovative sustainability pathways in the fruit-vegetable supply chain*". For this we will focus on innovations for sustainable food and nutrition security from the consumer perspective rather than the production side. In other words, ways to change people's behaviour to increase fruit and vegetable intake. The main outcomes of Deliverable 5.3 are several innovation pathways for fruit and vegetable consumption and to provide the relevant background in order to understand the complexity of these.

In addition, in deliverable 5.3 we describe the first exploration of the *uptake of those innovations in the SUSFANS models*. This exploration will be the basis for a stakeholder consultation on strategies and actions for moving forward. And the essence of the complexities also supports the uptake of innovation pathways in the food system framework, via the scenario framework or quantification framework or both. We will argue that this consumer orientation in quantitative scenario analysis and foresight on the food system is both necessary and challenging. The outcomes of the deliverable can further be discussed under task 5.4 with the modelling teams. As such the case study has the dual role of galvanizing support for the prioritization and action planning of specific innovations; and the platform for testing the SUSFANS framework and providing proof-of-principle.

In EU food policy both health and sustainably issues need to be addressed which requires that policies handles with issues that are very different and sometimes conflicting. Trade-offs are likely to appear between the policy goals. The issues range from food production practice to health outcomes, environmental impacts, and business considerations. The SUSFANS conceptual framework describes these issues in four overarching policy objectives (described in D1.1 and adjusted in D1.3):

1. Balanced and sufficient diet for EU citizens
2. Reduction of environmental impacts
3. Competitiveness of EU agri-food business
4. Equitable outcomes and conditions

Outline of D5.3 and link to other work packages

The deliverable starts with the background of the current fruit and vegetable intake. In Chapter 1 we will describe the benefits of fruit and vegetable consumption. Then in chapter 2 we will describe the conceptual model of determinants related to fruit and vegetable intake. Furthermore in chapter 3 we will describe the mechanisms by which fruit and vegetable intake can be increased via consumer, production and circular strategies. Finally, innovation pathways will be described in chapter 4 combining several strategies and at different levels of the chain (consumer, production, circular). Furthermore, the implications and feasibility of the innovations and the assessment of the innovations with the SUSFANS toolbox will be discussed in chapter 5.

The circular strategy focusses on optimally using leftover streams as this contributes to increasing the circularity of the food system (also concluded in D3.3). This part brings together insights and data collected in WP2 (Food consumption and diets), WP3 (Food supply chains) WP4 (primary agricultural and fisheries production) and the stakeholder consultations (WP6). The output of the deliverable will be used mainly in 5.4. For each innovation, data from literature related to the environmental impact and the nutritional values are given. This data is needed for D5.4 in which complete assessment of the innovation pathways will be done using the toolbox developed in WP9 to quantify the metrics developed in WP1. At the same time, it should be noted that the toolbox is developed from a production perspective whereas this deliverable describes the innovation pathways from a consumer perspective. For these reasons implementation of the outcomes of this deliverable in the toolbox will be less straightforward than the outcomes of Deliverable 5.2.

1. Introduction

1.1. The benefits (and risks) of fruit and vegetable consumption

Systematic reviews and summary reports which are weighing and assessing the substantiation of the evidence conclude that there is convincing evidence on the relation of fruit and vegetable consumption with health related outcomes. From a public health perspective fruits and vegetables are considered to play a key role in providing a diverse and nutritious diet. An adequate consumption of fruits and vegetables reduces the risk of certain chronic diseases, including coronary heart diseases, increased blood pressure, metabolic syndrome, type 2 diabetes, and certain types of cancer (WHO 2013; WHO 2014; WCRF 2007, Dauchet et al., 2005; Dauchet et al., 2006; He et al., 2006; He et al., 2007). Fruit and vegetable intake is also related to mental health [input and references needed]. It was estimated that, in 2000, low consumption of FV was accountable for 4.9% of deaths worldwide (Hall et al., 2009).

Vegetables are generally rich in fibre and micronutrients and low in fat and protein which makes them healthy foods. There is a direct pathways between fruit and vegetables and health in terms of their nutritional profile and the nutrients they provide. Increased F&V intake is beneficial since they are an important source of nutrients such as carotenoids, vitamin A, vitamin C, vitamin E, lutein, lycopene, folate, potassium, and phytochemicals. The micronutrients that vegetables provide have been related to metabolic processes such as oxidative stress, blood pressure, and insulin sensitivity (see e.g. Fulton et al., 2016 for more details). At the same time, the lower risk of NCDs associated with F&V intake is not related to specific nutrient content or other components of the food, nor to specific vegetables or fruits which support the advice to eat a varied diet of fruits and vegetables.

In addition, fruit and vegetable intake has also a more indirect effect on health through a positive effect on the diet; higher vegetable intake is related to lower fat intake and higher vegetable intake does not increase the energy content of the diet (Fulton et al., 2016). In other words, the more vegetables people eat, the less their diet contains “unhealthy” food that are high in fat and energy (although some vegetables contain more energy than others). Research has convincingly shown that replacing high energy density foods (high energy per weight of food) with fruits and vegetables (low energy density) can be an important part of a weight-management strategy (WCRF, 2007). The mechanism behind this is either substitution or the influence on satiety (Rolls, 2014). In

contrast to the health benefits, eating fruits and vegetables also poses some health risks. For fruits high in carbohydrates (fruit sugars) and for population groups who eat a lot of fruit it might contribute to higher carbohydrates in the diet when eaten in addition or instead of unhealthy foods. Other health risks related to F&V intake could be the content of heavy metals and pesticide residues.

F&V consumption and sustainability

Like all consumer goods, the consumption of F&V impacts on e.g.: land use, water use, and greenhouse gas emissions. For example, the average impact on freshwater availability of 1 kg of exported Brazilian yellow melons is 135 l, with a large range depending on the growing season's production period (de Figueirêdo et al., 2014). However, in general, eating in accordance with the recommendations for fruit and vegetable intake does not affect the environment in a negative way (Reynolds et al., 2014). From an environmental perspective an increased fruit and vegetable consumption together with other plant foods can support environmental benefits if a concurrent reduction in the consumption of animal-based foods is taking place (European Union 2014; B. Burlingame 2012; FAO Food Climate Research Network 2016; Garnett 2014; Ranganathan et al. 2016). From sustainability point of perspective an optimal sustainable diet includes a balance of most plant based protein and little animal based protein (van Kernebeek et al.,2015). See also figure 1 in SUSFANS deliverable 5.2. At the same time, Reynolds et al. (2014) concluded in their review of literature that more in depth research is needed on the establishment of the environmental impacts of animal-based foods, and fruit and vegetable intake. In this deliverable we focus on the aspects related to the consumer perspective. For example, the consumption of seasonal, local or exotic fruits transported by plane.

Dietary recommendations for fruits and vegetables

Recommendations for fruit and vegetable consumption are at least 400g, equating to 5 portions, per day (World Health Organisation, 1990; Cox et al., 1998; Naska et al., 2000; Whybrow et al., 2006). These recommendations for daily intake of foods and nutrients are based on research on the relationship between food intake and health outcomes: randomised controlled trails and observational prospective research (Gezondheidsraad, 2015b). These advises are country specific and are focussed on the main diseases in the country and tailored to the current diet. The World Health Organisation recommends 400 grams of fruits and vegetables per day, while other national bodies recommend 500 g of fruit and vegetables per day (France), or 600 g/d (Denmark)(http://www.fao.org/nutrition/nutrition-education/food-dietary-guidelines/en/). The differences reflect some variety in definitions, e.g. if legumes, nuts etc. are included.

In addition, more general advices at food group level are also formulated. For example, in The Netherlands, the Dutch Health counsel advices to eat a more plant-based and less animal-based diet (Gezondheidsraad, 2015a).

1.2. Fruit and vegetable consumption in Europe

Overall, the current dietary consumption patterns in Europe are characterized by a higher than required intake of energy (calories), protein, including animal protein, saturated fat, and added sugar. Concurrently, the dietary intake of dietary fibre, certain micronutrients (e.g. vitamin D, folate; iodine and iron (the latter in certain sub-groups of the population) is too low (see Mertens et al. 2017, Deliverable 7.1). At the same time, the EFSA and FAO data also show that the fruit and vegetable intake in Europe differs considerably between countries and remains below the level recommended. Mertens et al. (2017, SUSFANS deliverable 7.1) explores in more detail the dietary patterns in the four case study countries based on the national food intake data. Intakes of fruit and vegetables varied between countries. In particular, mean fruit intake ranged from 118 to 215 g/day, and vegetable intake from 95 to 258 g/day, all representing lower intakes for Czech Republic, moderate intakes for Denmark and France, and higher intakes for Italy.

There is thus a wide variety in consumption patterns across the four countries showing the limitation of drawing conclusions from average consumption levels. Food consumption patterns are clearly country-specific. Italy stands out in terms of fruit and vegetable and shares with France a preference for vegetables over fruit; the Danes and Czech population consume more fruits than vegetables.

All of the four countries have below-satisfactory adherence to the dietary guidelines for fruit and vegetables, for the purpose of this research defined at a daily intake per person of at least 200 gram of vegetables and 200 gram of fruit. Less than 20% of the population meets the guideline for fruit and vegetables consumption in Czech Republic and for vegetable consumption in Denmark. Around one-third of the population meets the recommendation for fruit in Denmark and for vegetables in France. Even for fruit consumption in Italy, adherence is below two-thirds.

In addition, differences exist between demographics groups. Mertens et al. (2017) report that the elderly consumed more fruit than young and middle-aged adults in all countries, and more vegetables in France, but less in Denmark. Women consumed more fruit and vegetables than men in all countries. Lower educated subgroups consumed less fruit and vegetables in France. Subgroup comparison by overweight status revealed no clear differences for fruit and vegetables.

There is limited insight if such differences are indicative of a future trend. It will be described in SUSFANS WP 5 and 7 for a number of European countries and should be taken into consideration. Relevant trends include:

- the changes of dietary patterns over the past years and increasing or decreasing of vegetables and fruit intake;
- types of fruits and vegetables eaten, such as more or less tropical fruits, local fruits and vegetables, seasonal, organic, convenience foods, ready to eat etc.;
- trends in meal patterns (cold bread meals/ hot meals, eating out of home/lunch packages.
- trends on background variables such as barriers to eat F&V, societal changes, income, habits, available time for preparing food, out of home consumption etc.

All such trends are relevant when considering innovations in the fruit and vegetable supply chain.

Table 1. Standardised food group intakes and the adherence to their corresponding food-based dietary guidelines in the selected four EU study populations, aged ≥ 18 years1.

	Czech Republic		Denmark		France		Italy	
Survey year	*2003*		*2005-08*		*2007*		*2005-06*	
	Mean	*%adh*	*mean*	*%adh*	*mean*	*%Adh*	*mean*	*%Adh*
Vegetables	95	10%	112	21%	157	37%	224	58%
Fruit	118	20%	133	35%	90	26%	177	45%

Source: Reproduced from Mertens et al. (2017), Table 2.

Note: %adherence represents a proxy for the percentage of the population that adhere to food-based dietary guidelines. The guideline corresponds to ⩾200 gram per capita per day for fruit and ⩾200 gr/cap./day for vegetables

1.3. Innovation strategies – what types of innovations are needed?

In deliverables 5.1 and 5.2 initial ideas on innovation strategies to improve the diet towards more healthy and more sustainable were introduced. Here we describe what we mean with innovation strategies and what types of strategies are needed. In chapters 3 and 4 the strategies and pathways will be discussed.

Goal of the innovations: Towards more fruit and vegetable consumption and a higher consumption of plant-based food in general

EU citizens on average consume too much energy and livestock products, while consumption of seafood and fruit & vegetables could be increased (SUSFANS deliverable 5.1). In the SUSFANS project, current dietary patterns are compared to recommendations to get more detailed insights in the discrepancies. At the same time current agricultural production, transformation and distribution systems have negative environmental impacts. In 5.2 innovation strategies to reduce intake of animal based foods is described and here we will focus on strategies that contribute to an increased fruit and vegetable consumption. Partly, the same strategies will apply to both fruit and vegetable consumption. But also, vegetables and fruit will be described separately since there are quite some differences with regard to consumption moment, perceived price, and nutrient content.

Strategies: consumption side, production side, circular

Environmental and nutritional challenges can be addressed by implementing mitigation strategies on the consumption or the production-side, or both. Consumption-side strategies are innovations that focus on changing the human

consumption patterns while production-side strategies contribute to a healthier and more sustainable diet by changing the production of food items without having an impact on the consumption patterns (Gerbens-Leenes and Nonhebel, 2002; Godfray et al., 2010; Foley et al., 2011; Garnett, 2011).

More specifically, consumption-side strategies focus on changing consumption patterns in order to increase fruit and vegetable intake. Production-side strategies can focus on reducing the environmental impact per kg of fruits and vegetables through technical innovations. For example, innovations related to product characteristics such as price, quality, taste, size, etc. and related to cultivation strategies such as higher yield, better growing, transportation and storage. Another example of production-side strategies could also be to increase the nutrient content (e.g. vitamin content) of fruits and vegetables. Innovations in distribution, marketing, and regulation are somewhat in between since they are on the production side but with the aim to influence consumption patterns. Combined strategies are for example the producing fruits and vegetables with improved taste combined with promotion of consumer preference for these products. A third strategy is the circular strategy, which focusses on improving the circularity of the food system, and lies in between the production-side and consumption-side strategies (Schader et al., 2015). For example food waste has both consumption and production aspects. From the consumption side this includes reduction of food waste related to buying, transporting and storing as well as preparing and processing.

Example of consumption, production and circular innovation supporting strategies towards a healthier and more sustainable diet

An example of how innovations could support strategies that contribute to a healthier and more sustainable diet is described in figure 2 of SUSFANS deliverable 5.1 (see Figure 1 below). First consumption side strategies are needed to shift the current diet to a diet that is in line with the nutritional guidelines this can be done in many different ways. Such a healthy diet would provide benefits both in term of health and sustainability. Then, though technical innovations at the production side the healthy diet can become even healthier through for example fortification. Or even more sustainable through innovation at the consumption side (e.g. replacement of food products such as replacement of tropical fruits by local fruits or substitution of energy dense snacks by fruits or vegetables), production side (e.g. feeding strategies or more relevant for fruits and vegetables cultivation strategies), or circular (reduce waste).

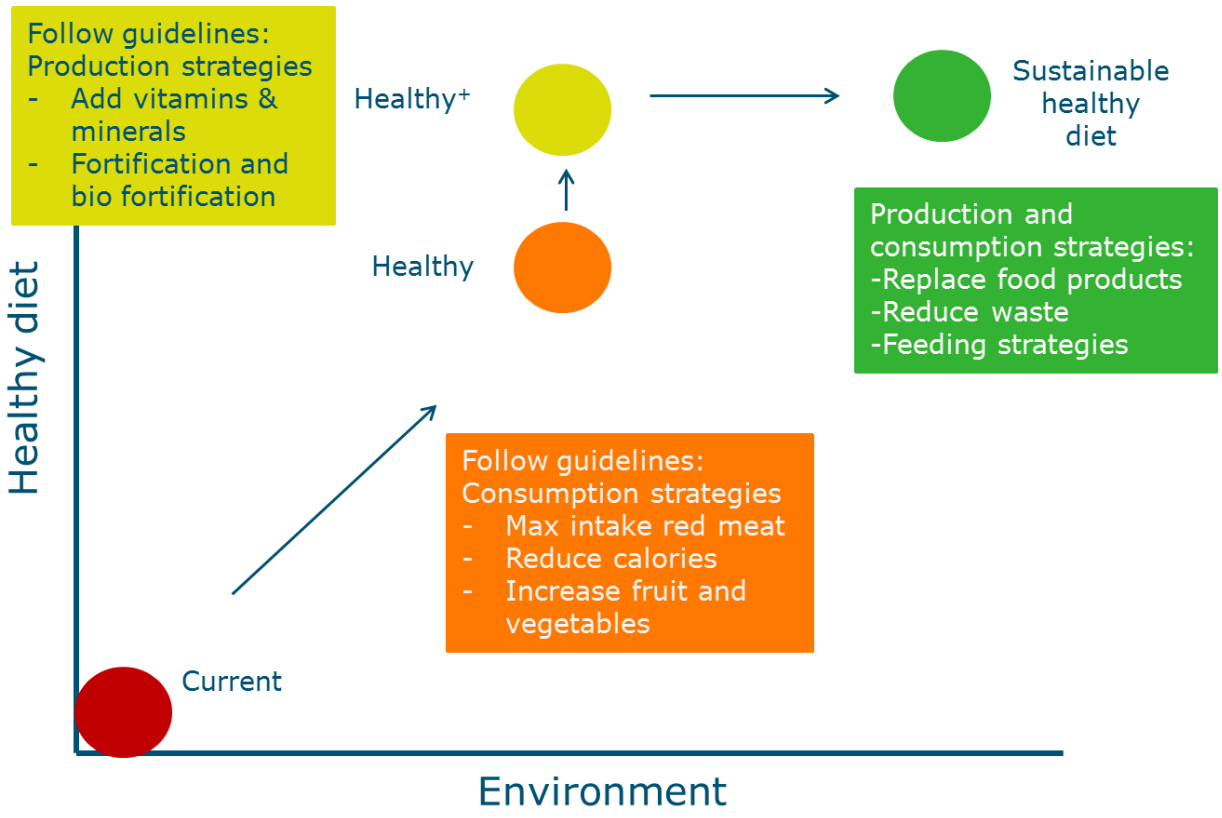


Figure 1. (Copied from D5.1, figure 2 on page 22): Example of how innovations can help to reach heathy and planet-friendly diet

2. Focus on Consumers perspective – explaining fruit and vegetable consumption and perception

In order to be able to design strategies to change consumer behaviour, in this case consumption patterns, one has to understand the drivers of this behaviour. In this chapter we will describe the main determinants of food consumption. This overview shows all kinds of elements which might give opportunities to increase fruit and vegetable consumption by means of policy or innovation. First, we will discuss the model by which the determinants can be structured.

This overview of models as well as the list of innovations is based on literature, expertise and the input from an internal workshop with colleague consumer, marketing and chain researchers. They especially provided us with examples of innovations.

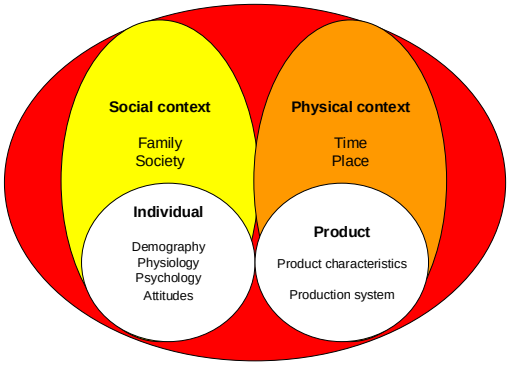
2.1. Model - person and product in their social and physical context

When considering food consumption and perception this is always a result of a combination of different determinants. For example, the individual and his or her characteristics, the social environment in which this person behaves, the product with its characteristics and the way of production and the physical context in which the food is bought and eaten. Frameworks have be designed to structure the wide range of variables related to food consumption. Generally, these models differ in:

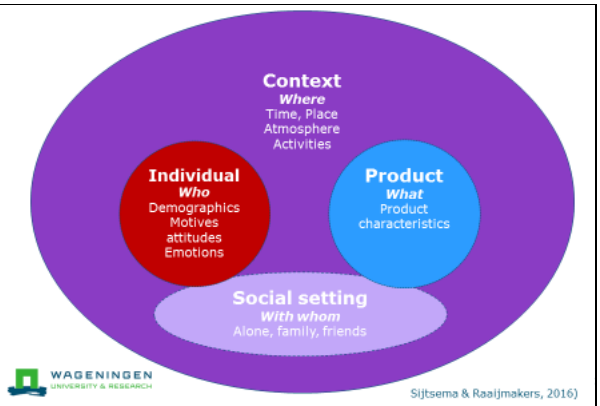
- Their focus on the food production chain or the consumer
- Their focus on both consumer and product or product as part of the food environment of the consumer
- The number of levels for environment: such as a separate level for context level and system level
- Most of them consider consumption behaviour but also perception is possible.

Figure 2 shows some examples. For the purpose of this paper we chose a consumer focussed model (rather than food chain) with consumer and product separately, including context level and governance level. We strongly build on

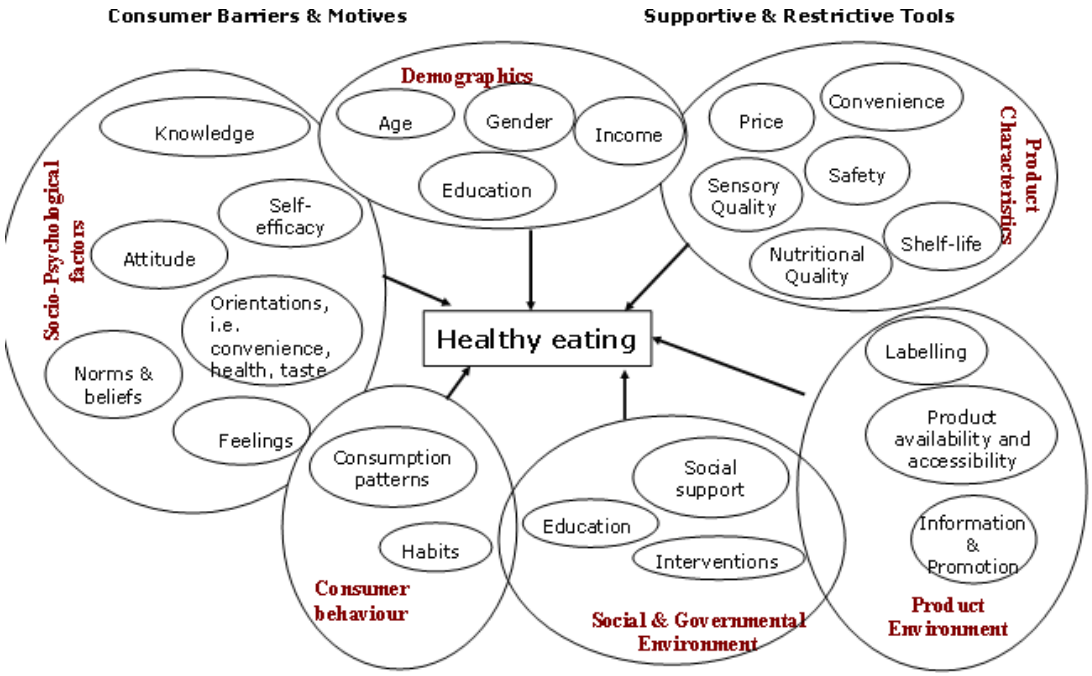
the DONE framework but with product as a separate category rather than as a part of the physical environment.



Model based on adjusted from thesis Sijtsema (2003)



Consumption moment model (Sijtsema and Raaijmakers, 2016)



Determinants of healthy eating (Snoek, Reinders, and Zimmermann, 2010)

Figure 2. Examples of some models that describe determinants of intake

DONE framework: Determinants of Nutrition and Eating

In the recently finished project DEDIPAC a broad group of European researchers studied determinants of diet and physical activity. One of the outcomes of the project was the DONE framework (Figure 3) which stands for Determinants of Nutrition and Eating (Stok et al., 2017) and which is available online on

https://www.uni-konstanz.de/DONE/. The DONE framework was created by an interdisciplinary workgroup in a multiphase, multimethod process. In this framework, the main categories of determinants are: individual, interpersonal, physical environment, and policy. It differs from the other frameworks in the way that product is part of the physical environment dimension and that social, cultural and policy (governmental and industry) environment are split. Also, the individual domain compresences a broader field with also biological and situational determinants. For each of the domains several subcategories of determinants are defined. See https://www.uni-konstanz.de/DONE/view-interactive-data/.

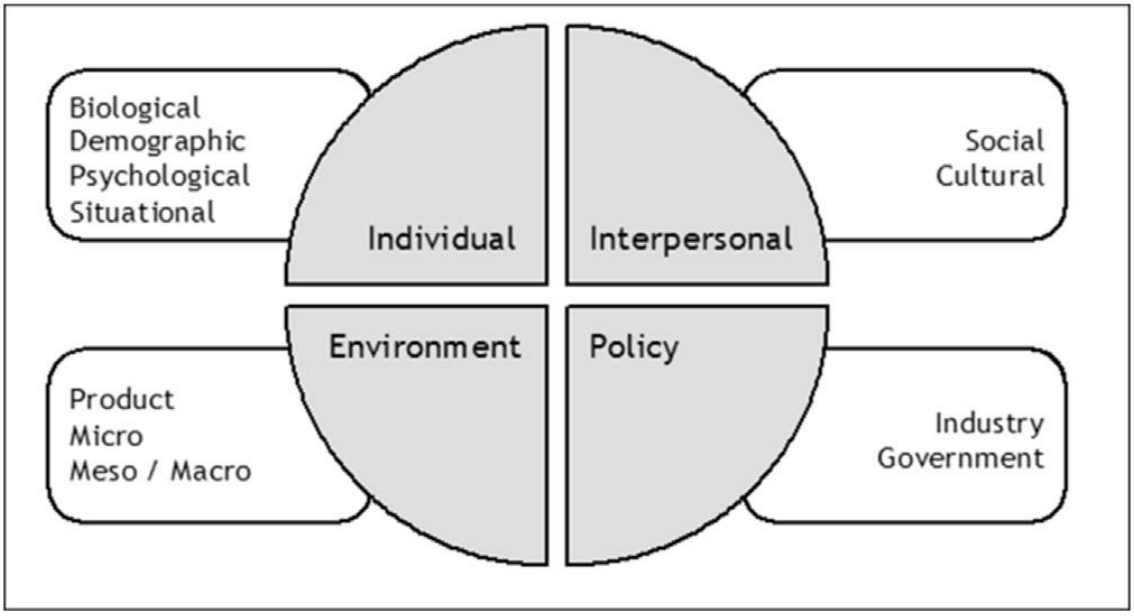


Figure 3. Simplified representation of main levels (grey) and stem-categories (white) in the DONE framework. Copied from Symmank et al., 2017.

2.2. Individual

The dietary pattern of individuals consists of the consumption of several product groups of which fruits and vegetables are one of it next to drinks, bread, grain/wheat and potatoes, dairy, fish, legumes, meat and eggs, fat and oil. The actual consumption of F&V differs per person and is influenced by the following variables:

Biological

- Preferences (taste preferences)
- Physical health (diabetes)

- Anthropometrics (weight status, chronic disease)

Demographic

- Health inequalities (socio economic status differences)
- Life course perspective (age: children, elderly; life events: pregnancy, young parents)

Psychological

- Habits (eating pattern, routines)
- Motives to buy food (egoistic motives: price taste health and altruistic motives: animal welfare, fair-trade, environmental friendly)
- Orientations (convenience, price)
- Innovativeness and food neophobia (product: new types of fruits or vegetables and production and processing related: nano, GMO, LED light)
- Health perception and need to eat F&V (content and differences between types of F&Vs, relevance for themselves)
    - Image of eating fruit and vegetables (eating fruits is dull or doesn't fit with social norm)
    - health related motive orientations (HRMO)
- Knowledge
    - Lack of knowledge about:
        i. recommendations
        ii. amounts one should eat
        iii. effect of eating F&V
    - Lack of education on healthy eating habits with more F&V
    - Overestimation of own consumption, gap between what they think they eat and what they should eat
    - Lack of knowledge on food production processes in relation to fruit and vegetables and their consequences for health and environmental impact
- Price
    - Lack of willingness to pay for F&V in general or more healthy and/or sustainable specific
    - Lack of means to afford some of the F&V products - particular issue in vulnerable groups such as low SES.

2.3. Product

Product characteristics can be divided in intrinsic and extrinsic, intrinsic are linked to product itself, like colour, taste, while extrinsic characteristics can be added such as price and brand. And there are product characteristics one can judge oneself or ones you should trust on such as safety or organic produced.

2.3.1 Intrinsic

- Product characteristics (taste, price, quality, freshness, shelf life)
- Constant quality over time
- Production system, processing (dried fruit) and breeding.
- Convenience with regard to preparing (cut, sliced) eating (juiciness, to be peeled, size), storing (fridge, ripe and ready to eat), transporting (packed, easy to bring).

2.3.2 Extrinsic product characteristics

- Branding and marketing (difficulties in promoting consumption of fresh F&V as there a both branded and unbranded products on the market)
- Perceived satiety and energy content (light products)
- Health claims, logo (country of origin)

2.4. Interpersonal: Social environment and cultural environment

- Social environment (alone, with friends or family members or colleagues)
- Social norms
- Cultural differences (traditions of eating vegetables for lunch or not)

2.5. Physical environment

Micro environment / context

- Place (at home, out of home such as canteens, day care schools, restaurants etc.)
- Time (meal type, time of the day)
- Situation (household, school or work)

Meso and macro environment

- Availability of fresh F&V in shops in the different EU regions
- Availability out of home e.g. on the go
- Overall lack of a supportive environment
- Societal issues (due to changes in family working hours less time for cooking and preparing, need for convenient foods)

2.6 Policy

Industry

- Promotions
- Sustainable living plan

Government

- Regulations
- Campaigns
- Information

Systems level

Several strategies related to increases in consumption of fruits and vegetables have been promoted, including strategies related to public policies, the food system and the consumers (CDCP 2011). Some approaches present a systems approach in the sense that they go beyond targeting consumption behaviour alone; strategies may also aim to remove an underlying barrier in food supply or socioeconomic inequality. The public policies include e.g. the official food based dietary guidelines supporting fruit and vegetable consumption and programs like e.g. the European 5 A Day-type type programs on increasing awareness and availability (WHO 2003). Strategies related to the food system include e.g. expansion of farm-to-institution programs in schools, hospitals, workplaces, and other institutions and expansion of community supported agricultural programs (CDCP 2011). Finally, examples of strategies targeted consumers include e.g. changing the accessibility by economic incentives, availability by school or work place programs (Wind et al. 2008; Lassen et al. 2004).

3. Innovations

There are several ways to support the increase of fruits and vegetables. The former chapter shows that there are numerous determinants and variables related to consumers' behaviour that could be targeted on. In this chapter an overview is given of potential or already applied innovations to stimulate consumption of fruit and vegetables, structured according to three possible innovation strategy: Consumer side innovations needed to go from the current diet to a healthy diet that is in line with dietary and sustainable recommendations (paragraph 3.1), product and production (3.2), and circular innovations (3.3). These innovations describe ways to influence behaviour via the different determinants described in the DONE model both directly aimed at one determinant or through a combination of determinants from similar and/or different levels of the model.

3.1 Consumption related innovation

As mentioned in the introduction current consumption levels are not yet in accordance with the recommended levels. Still a considerable increase is needed to reach the recommendations. This paragraph introduces several innovations to support increasing fruit and vegetable consumption. These innovations target towards increasing the consumption to meet the dietary guidelines from official authorities of 400 – 600 g of fruits and vegetables per day.

Increasing consumption or in other words changing the diet towards one with a higher intake of F&V can be reached in several ways for example eating bigger portions or more varieties of fruits and vegetables. Different diets to increase F&V intake are Vegan, Vegetarian, meat partially replaced by plant based foods, meat partially replaced by mixed food, balanced energy intake and healthy diet (Halström et al 2015). In the personal diet increasing fruit and vegetable consumption might have different consequences. The person overall eats more, or some other product groups might be substituted. For example when a person is aiming to eat less animal based food and chooses more plant based food. Or when one is eating fruits instead of sweet energy-dense snacks. Thus we should be aware that there are different effects on the diet.

In addition, consumption related innovations can change intake without necessarily changing the diet. For example, innovations can facilitate consumption of products that are better tailored to consumer needs such as convenience, size, time of the day, etc.

Targeting different groups of consumers

Interventions and programs aimed to increase fruit and vegetable intake can be targeted at certain groups of the population instead of the population as a whole. Already for decades targeting based on **demographics** such as age (kids and elderly), region, urban and rural and education level is applied. One of the most known examples are interventions targeted at school children, such as school fruit programs (e.g. Evans et al., 2012) or interventions in the school food environment (e.g. Driessen et al., 2014). Also, there is a large amount of programs aimed to reduce health inequalities of people with a lower socio-economic status (SES) or low income (Bull et al., 2014). Next to this also taking notice of specific life events such as pregnancy may be useful.

Recently also other consumer characteristics such as **attitudes, orientations and intentions** are applied in targeting. For example, Verain and colleagues (2016) showed that different segments of consumers can be identified based on the importance that they attach to health and sustainability in their food choices. Also, different segments of consumers have been identified based on their health related motive orientations which is the meaning that people attach to health (Roininen et al., 2001, Geeroms et al., 2008, Raaijmakers et al., submitted) or to their convenience orientation.

Personal preferences, for example related to taste and preferences for specific products are another way of targeting. Wansink et al., (2006) presented the sweet tooth hypothesis: people who frequently eat sweet snacks may also eat fruits. A study in four EU countries showed that consumers with a self-reported sweet taste preference eat more sweet snacks and consumers with a self-reported sour taste preference eat more fruits and fruit products (Sijtsema et al., 2012). These personal preferences can also be barriers, for example children avoiding eating vegetables due to bitter taste (Zeinstra et al., 2007) although repeated tasting improves liking of vegetables (e.g. Wild et al., 2015).

Next to this targeting, it will be helpful especially taking notice of **health status, body weight**, and more vulnerable groups such as people suffering from diabetes or cardiovascular diseases.

Another way to target interventions is to look at people's willingness to change, or their awareness of for example health issues. The idea behind this is that people need different things based on how far they are in the process of

changing, also referred to as **stages of change.** The degree of effectiveness of such tailored interventions is still topic of debate (Noar et al., 2007; Pope et al., 2017).

Thus innovations seem to have a higher impact when targeted to specific groups of consumers. Despite these insights however, efforts to increase fruit and vegetable consumption so far have not been effective enough to reach the recommended levels of intake.

Motivation, opportunity, and availability

A well-known model to describe the aspects related to behaviour change is the motivation – opportunity – availability (MOA) model (Ölander & Thogersen, 1995). In this model, motivation represents the individual's willingness to change behaviour; opportunity the environmental or contextual mechanisms that enable behaviour change, and ability the individual's skills and/or knowledge that enable behaviour change (Rothschild, 1999). There are several motives to take into consideration, for example the egoistic motives such as price, taste and health most often referred to as the most important ones for food in general. And altruistic motives such as animal welfare, environmental friendly which used to be least relevant but the importance is increasing show studies of Voedselbalans and Agrifoodmonitor (Onwezen et al., 2011, 2016). In addition, research by Verain et al. suggests that the importance of motives might differ between product categories (Verain et al., 2015).

Most literature on the factor opportunity focusses on the physical food environment. The social aspects of the food environment are described in the next paragraph. Physical food environment can be evaluated at a more general level such as the density of supermarkets, food outlets, etc. in neighbourhoods or at a more specific level such as types of foods available in the supermarkets, prices, portions sizes, etc. There are several reviews that show some degree of association between food outlet availability (density) and obesity (e.g. Cobb et al., 2015). A review by Black et al. (2014) showed that in the US better access to supermarkets and greengrocers was associated with healthier dietary patterns whereas negative associations were found between small grocery stores and convenience store with fruit and vegetable intake. For Europe however mixed results were found (Black et al., 2014). Another example of opportunity is that in

Balkan countries the consumption of fruit is rather high due to the relatively high amount of home grown fruit (Sijtsema and Snoek, 2010).

An aspect that is related to all three dimensions of MOA is price. Price is an important motive for people for food choices in general and vegetables and fruits in specific (e.g. Onwezen and Bartels, 2011) although differences exist between countries (SUSFANS deliverable 2.3). In line with this, people tend to choose the cheaper option in experimental and observational studies. For example in the SUSFANS deliverable 2.3 price was a main driver of choice for fruit and vegetables in a choice experiment in all countries and for all products included. Price played a bigger role in consumer choices for fresh products compared to frozen products and for fruit products more than for vegetables. However, between consumers, the influence of price was limited, no differences were found between demographic groups except that price was a stronger driver for food choice in The Netherlands and less strong in The Czech Republic, and for respondents with a medium level of education, price was a less stronger driver compared to lower or higher educated respondents. This suggests that price reduction might be an appropriate innovation for specific target groups.

At the same time, the impact of price in a real-life setting should not be overestimated. Price, is not the only important food motives, generally health and taste score highest but there are differences between individuals and situations. For example, people tend to make different choices at certain times (e.g. young parents), for certain products, and in the context of emotions, situations, etc. Other factors that relate to this are the perception of the price of fruits and vegetables (especially for fruits) and willingness to pay. Willingness to pay was also mentioned in the SUSFANS workshop as an important factor (see Deliverable 5.1). At the level of context / opportunity, it seems that the relationship between price and dietary pattern is not straightforward. In the review study by Black et al. (2014) the reviewed studies showed mixed results with both higher and lower prices in deprived neighbourhoods and, surprisingly, a trend towards better dietary patterns when prices of healthy foods were higher.

Finally, the effectiveness of food taxes and subsidies has been the topic of debate in numerous reviews. An (2013) and Thow et al., (2014) concluded that there is support for the effectiveness of taxes and subsidies in improving diet

quality although the number of prospective and large-scale studies is limited. A more recent review by Afshin et al. (2017) found similar results based on only prospective studies. Similarly, Powel et al. (2013) found that lower fruit and vegetable prices were generally found to be associated with lower body weight outcomes among both low-income children and adults, suggesting that subsidies that would reduce the cost of fruits and vegetables for lower-socioeconomic populations may be effective in reducing obesity. This might be especially effective when taxes and subsidies are implemented together (Niebylski et al., 2015). Price interventions seem especially effective for people with a lower socio-economic status, however the majority of the studies does not differentiate between groups (McGill et al., 2015). Finally, while research suggests that the effects on diet are modest, food taxes and subsidies by themselves are unlikely to affect food consumption to such a degree that it will influence individual weight or obesity prevalence. Food taxes and subsidies may be an opportunity as part of a multifaceted approach to reduce obesity incidence, thus in combination with multicomponent interventions (Thow et al., 2014; Finkelstein et al., 2014; Afshin et al., 2017).

Even when people are motivated and the context does not pose significant constraints they still need to have the ability to perform healthy behaviour. Ability related to knowledge and skills. Knowledge will be discussed in one of the next paragraphs. Other aspects related to ability is self-efficacy which is ones belief that he/she is able to conduct an certain behaviour such as buying, preparing and eating healthy foods. Interventions to increase self-efficacy have positive outcomes on diet-related behaviour. Prestwhich et al. (2014) reviewed how self-efficacy can be increased via social (e.g. rewards, social support) and practical feedback (e.g. planning). Another aspect of ability is self-control and the ability of self-regulation of food intake. Generally, self-control has been related to positive outcomes but also negative unintended effects might occur. In the food domain it has been associated mainly with positive outcomes, for example on weight management (Johnson et al., 2012) and can be seen as ability factors.

Thus, additional to characteristics and attitudes at an individual level also context (opportunity) should be taken into account and one's motivation, opportunity and ability to perform healthy behaviour. Possible pathways are: increase availability, (decrease price), increase ability by for example self-

efficacy. Price taxes and subsidies should be combined with multifaceted approaches to have considerable influences on overweight and obesity rates.

Considering social context - Cultural identity

Innovations should take also the traditions with regard to appropriateness of consumption moments and places into consideration since fruit and vegetable consumption **habits and traditions** may differ between and within countries. In The Netherlands, for example, vegetables are eaten almost exclusively during dinner (van Rossum, 2016). Therefore, eating vegetables during other meals and/or at other times of the day could be a way to increase intake but some barriers have to be overcome.

In order to understand and change habits the link with situation or context is really relevant (Riet van't et al., 2011). A study of Onwezen et al. (2012) shows that different groups of consumers attaches different value towards attributes in different situations.

A specific aspect of the social context is the **social norm.** Social norm refers to people's perception of the behaviour and attitudes of „others". These others can be both in general (people from their country) or more closely related to them (friends, family, co-workers). Social norms are strongly related to food choice behaviour both in terms of types of foods and quantities and has been used in experimental studies to influence behaviour (Robinson et al., 2014; Stok et al., 2016). However, also negative outcomes can occur and the effectiveness of social norms in influencing behaviour could be restricted only to eating in absence of peers and is dependent of the framing of the norm (e.g. forcefulness) and behaviour related aspects such as habit strength (Stok et al., 2016). An important distinction in this is the differences between descriptive social norms that describe appropriate behaviour and injuctive social norms that describe the acceptance or unacceptance of behaviour by others (Cialdini et al., 1990). Social norms may affect food choice and intake in two way. First, self-perceptions are influenced by rewarding and disapproval by others since compliance with social norm is related to social judgement. And second, sensory / hedonic evaluation (as well as safety) of foods are influenced in the way that people learn from other peoples preferences (Higgs, 2015).

Thus people behave within a social context and are susceptible for social approval and disapproval. Therefore habits and traditions should be taken into account and social norms can be a potentially powerful instrument in behaviour change though it is difficult to influence on the long term and across different contexts (eating alone versus with peers).

Communicating to inform (or improve knowledge)

Rothchild (1999) pointed out three strategies to change behaviour: Education, marketing, and law. Law has been discussed before in relation to taxes and subsidies. In this paragraph we focus on communication which includes education and marketing but is broader and also includes other forms of information. We choose for this broader perspective since knowledge (education) by itself is not enough to change behaviour and also, providing knowledge by itself does not assure that people will assimilate this information.

In order to change behaviour towards a higher compliance with dietary advice one has to be familiarity with those guidelines. Consumers differ in their interest for such information guidelines, partly also because they tend to overestimate their own consumption of fruits and vegetables. Self-perception and self-insight are thus of importance in order to be susceptible to information. In addition, although people generally perceive vegetables as healthy they differ in their perception of the healthiness of specific nutrients in fruits and vegetables (e.g. specific vitamins), in their knowledge perceptions of the effect of nutrient content of vegetables (e.g. fibre) and, most importantly in their perception of how strong their behaviour is related to health outcomes (Sijtsema, et al, unpublished data on consumer perceptions of vegetable with extra nutrients). Also in the SUSFANS workshop described in D5.1 perception healthiness of fruit and vegetables, lack of education, and lack of knowledge were mentioned as main issues for fruit and vegetable consumption. This information is closely related to the perceived abilities as expressed above from MOA (Ölander & Thogersen, 1995). At the same time, although the level of knowledge of consumers is sometimes low, education can only be a solution if people are willing to assimilate this information and if it is provided to them in the right context and in an appropriate way.

Then, if people are open for information this information should by suitable for them and come from a trustful source. General campaigns can be targeted

towards raising awareness, habits, informing etc. But there are numerous possibilities to target or even personalise advice to the person's situation (e.g. diseases) and preferences (e.g. motives, taste). In addition, there are other ways to reach people, for example by adding nutritional information to recipes, apps, add health claims, or product information, sustainability logo's etc.

Finally, the level of information is also of importance, one could trigger consumers for health in general or nutrients such as vitamin C or antioxidants more specific (Ronteltap et al., 2012). In Susfans deliverable 2.3 the outcome a choice experiment clearly showed the preference of consumers for more specific rather than general information about the healthiness and sustainability of fruits and vegetables.

Thus, knowledge and awareness is a route to involve consumers with fruit and vegetable intake for decades. It seems that underestimation of intake and lack of interest is a barrier for this route. In addition, messages should be targeted to people and their specific interests to bring this message more successful. At the same time, it should be mentioned that improving knowledge on its own is not sufficient to increase consumption. It is not a matter of education only, behaviour change is needed and people have to be willing and able to search and process information.

Improving acceptance of new technologies or new products

Consumer acceptance of new developments should be taken into consideration especially when new technologies are applied to innovations. Research by Ronteltap and colleagues shows that willingness to accept new technologies depends on characteristics of the product (e.g. food versus non-food), the context (e.g. geographic distance of production) and of the individual (e.g. risk perceptions) (Ronteltap et al., 2007; Ronteltap 2014). A recent study by Sijtsema et al., (unpublished data) showed that consumers have a higher acceptance rate of enriched fruits and vegetables if they do see the utility of the innovativeness and experience less risk.

Food neophobia can be seen as barrier to consumers' acceptance of novel food products. Food neophobia is measured by people's reluctance to try new foods (Pliner and Hobden, 1992). High scores on food neophobia have been related to

a lower acceptance of food innovations and innovative production methods (Barrena & Sanches, 2015).

When studying consumers' acceptance of new technologies one should also be aware about the lack of knowledge about food production and processes in general as well as related to fruit and vegetables and its consequences for health and environmental impact more specific (Sijtsema et al., unpublished data).

3.2. Product and Production innovations

This paragraph includes innovations with regard to the product itself, the production and breeding of the fruits and vegetables as well as the production chain and technological solutions applied to maintain or increase volume or improve quality or change other characteristics to meet demand for F&V or increasing efficiency (and decrease environmental impact per KG of F&V). Next to that also logistical or managerial improvements in the chain are seen as product innovations.

Product innovations

In order to reach consumers' needs and wishes or improve efficiency or sustainability of production there are several product innovations possible. Other or new varieties of fruits and vegetables could be developed which overall have a better quality or innovative characteristics. For example products with a longer shelf life, a better taste, or another colour (e.g. apple with red flesh or purple cauliflower). Fruits and vegetables varieties can also be improved in terms of higher amount of nutrients such as antioxidants. Varieties of fruits and vegetables with a higher yield might result in cheaper products for consumers. Other examples of innovations are varieties which make an extended local season, for example for strawberries or berries, or varieties which more easily grow under more sustainable production systems. And in addition to developing new varieties, also fruits and vegetables which aren't on the European market yet could be introduced such as new types of green leafy vegetables from other continents.

Packaging and branding

In terms of packaging, tailoring to channel and purpose can be improved as well as sustainability of the package and branding of fruits and vegetables.

Fruits and vegetables are sold via different channels, varying from mainstream supermarkets, on the go and several online possibilities each showing a need for different package size and look. Rather than using the same package in every situation, the package could be tailored to the channel and the purpose. Second, packaging could also be improved with regard to sustainability, and, more specifically recyclability or composability. For example through bio-based packaging such as the use of greens of tomato plants for packages of tomatoes. Finally, branding of fresh fruits and vegetables provides opportunities for innovations. Generally only a few brands are available for fresh fruits and vegetables such as Chiquita and Zespri. Branding or labelling might be a way to communicate with consumers about constant quality, good taste, ready to eat or other product characteristics.

Processed products

Besides stimulation of fresh fruits and vegetables also the consumption of processed fruits and vegetables might be a route to follow. This might be of interest especially for those consumers who are more convenient oriented. Next to that processing might be needed to make use of seasonality of a large amount of vegetables and fruits.

Innovations opportunities for processing are the production of fruits and vegetables with improved quality, avoiding nutrient loss, safer and or more convenient with regard to portion size or storability. The quality (e.g. taste and nutrient content) of processed foods such as frozen or canned fruits and vegetables, and dried fruits (and vegetables) can be improved. But also fruits and vegetables can undergo (minimal) processing resulting in products with for example improved self-life but very similar to fresh products. Examples of processing to increase convenience are: Freshly squeezed juices from fruits and or vegetables and pre-cut or sliced fruits and vegetables. An example of both convenience and health improvements is (minimally) processed F&V, reducing preparation time and with higher nutrient content. Another example related to health is the use of hybrid products where part of a meat product (e.g. burger) or staple food (e.g. pasta or pizza) is substituted with vegetables or legumes. These innovations can serve the needs of consumers who want to improve their diet (e.g. eat less meat) but without changing their habitual products. Also, for those consumers not fond of vegetables at all this could be a way to increase

intake. Finally, the portion size of F&V in ready-to-eat meals could be higher and more in line with recommendations.

Production chain

Not only the product itself but also the production chain should be taken into consideration for innovations, for example in the case of quality improvement. These innovations relate to transport, seasonality, and use of resources. Examples related to transport are the distance of transportation, the country of origin, and improved logistics. Examples related to seasonality are the optimization of seasonality and extended local seasons. Also, due to climate change and improved production different exotic products (such as exotic fruits) are now available from different regions. For example, nowadays avocados are also available from Spain. Improvement of use of resources is relevant to both conventional and organic production system and include:

- Less use of pesticides,
- More efficient growing systems,
- More sustainable greenhouse systems e.g. with earth warmth, closed and semi-closed systems,
- Breeds that are more resistant to diseases, whether this is with or without the use of GMO is subject to debate,
- More efficient use of available space, for example via vertical farming.

Finally, an important aspect of sustainable product in the chain is the social welfare of workers during planting, growing and harvesting fruits and vegetables.

3.3 Circular innovations

Next to consumer and product innovations there are also strategies aiming at a more efficient and sustainable use of resources by means of making use of all rest streams in the production chain as well as avoiding waste of fruits and vegetables as much as possible.

Rest streams

Innovations related to rest streams include the use of F&V for animal feed, package or other. These innovations do not necessarily relate to increased consumption but result in more efficient sustainable production.

Food waste

Lower level of food waste for F&V could be achieved in whole chain including the consumer. These innovations are mostly related to sustainability and do not necessarily relate to increase consumption. Although in some cases consumption might increase when consumers eat food that would otherwise have been thrown away. A substantial part of food waste occurs within household after buying. Innovations can be applied to planning, buying, storing, preparing and eating in order to choose or keep the right quality or ripeness. Not only consumers themselves waste food but also in canteens or restaurants consumer-related innovations are relevant. A possible action to avoid waste is to support consumers with their choice for the right quality or ripeness of the products. Another example is the purchase of products with different shapes, small irregularities or other criteria for quality differentiation. Next to these examples consumers should become aware of the right conditions for transport, storage and shelf-life. In addition awareness or innovations is needed to support consumers cooking the right amounts of food (e.g. measuring tools), and use of left overs or how to store them. Waste can be reduced for example by using parts of lesser quality for example leaves in soups and sauces, etc. Another aspect here is the quality judgement of products and consumers' disgust towards for example spots on food. Overall consumers differ in their level of knowledge and practical skills as well as disgust and openness towards for example using products or parts of products with lesser quality.

4. Innovation strategies and pathways – supporting fruit and vegetable consumption

In the previous chapters, we gave an overview of several variables and aspects related to consumption behaviour of food and the possible innovations related to consumers, products, and circular. Based on these, several strategies could be performed that combine innovations in order to increase both vegetable & fruit consumption, or fruit or vegetable consumption in specific. This chapter gives insight in innovation strategies and pathways with regard to increasing fruits and vegetables. In 4.1 we give an overview of possible innovation strategies which are combinations of actions were innovations from consumer, product, context or circular point of perspective can integrated. In 4.2 we propose some possible pathways to increase fruit and vegetables in general but also related to fruits and vegetables in specific. Innovation pathways are more long term and described innovations within the context of societal development. The topics described here are closely related or even show overlap with the previously discussed innovations. The structuring is meant to show the different and diverse possible combinations, it is not meant to be conclusive. Moreover we are not intended to be complete and for sure several other actions and pathways could be formulated.

4.1 Innovation strategies

In order to increase F&V consumption towards a more healthy and sustainable dietary pattern below several innovation actions are described.

Consumer related innovation strategies

- Support targeting: Combine groups of consumers with specific product, context, and tailored communication.
- Making consumers aware of their overestimation of own F&V consumption.
- Support providing information about F&V health perception towards specific target groups.
- Support of education schemes about nutrition and health impact, tailored at consumers' characteristics.

Fruits and vegetable related innovation strategies

- Support seasonal and local fruits and vegetables.
- Support the guidelines to eat less animal-based and more plant-based foods.
- Support more convenient easy to eat or prepared fruits and vegetables.
- Support availability of F&V in different outlets including online shopping.
- Support of fruits and vegetables with higher content of specific nutrients. Especially those nutrients for which intake is below recommendations, for example fibre rather than vitamin C.

Fruit and vegetable in context innovation strategies

- Support vegetables with larger portions in recipes and dishes.
- Support vegetables at other moments: snack vegetables.
- Support innovative varieties of vegies at regular moments.
- Support innovative varieties of vegies at new moments, for example snack cucumber.

Consumer choice of fruits innovation strategies

- Support of more local fruit instead of exotic.
- Support more seasonal fruits instead of imported fruits.
- Support to more convenient fruit and processed fruit products.
- Support to eat fruit instead of sweet energy dense snacks.

Consumer choice of vegetable innovation strategies

- Support local or seasonal vegies instead of imported or greenhouse vegies.
- Support to more convenient vegies and processed vegetable products.
- Support eating vegetables at other moments than the warm dish.

Circular related innovation strategies

- Support avoiding food waste.
- Support making use of waste streams.

Although these lists are not complete, the overview shows that most of them are solely related to improvement of the product fruits and vegetables itself. Others show the position of the fruits and vegetables in its context of buying or consumption. In addition to these, there are also some consumer choice

innovations such as the choice for seasonal instead of imported fruits. Next to these product-related innovations, there are also some consumer and circular related innovations mentioned. Overall, one should be aware that fruits and vegetables or product groups on its own with different nutritional characteristics, different contexts to be eaten and personal preferences.

4.2 Innovation pathways

This paragraph gives a description of and introduction to innovations pathways. These pathways combine the consumers, product, and circular perspective with communicational and or contextual factors as well as different scenarios. In practice, the three perspectives (consumer, product, circular) are not always represented in each pathways. Sometimes they go together, sometimes they do not and sometimes they move in different directions. The scenarios represent the societal, cultural, political context in which innovations occur. And it incorporates drivers that are more long term and beyond the level of this specific case; the healthiness and sustainability of the diet.

The EU SCAR (2015) report presents three scenarios in agriculture:

High Tech: represents a world dominated by large multinationals and advanced technology (ICT, robotics, genetics). It is characterised by globalisation, widespread use of unmanned vehicles, contract farming and outsourcing, with a large urban population. European institutions are strong, national governments are weak. In general it is a wealthy society, but inequality creates concern. Sustainability problems are largely solved through technical solutions such as precision farming and genetic modification (GMO);

Self-organisation: a world of regions where new ICT technologies with disruptive business models lead to self-organisation, bottom-up democracy, short supply chains and multi-forms of agriculture. European institutions are weak, regions and cities rule and follow quite different pathways for agriculture. Products are traded between regions. There is inequality between regions, depending on endowments;

Collapse: a world where climate change, mass-migration and political turbulence leads to a collapse of institutions and European integration. Regional and local communities look for self-sufficiency. Bio-scarcity and labour-intensive agriculture, including permaculture and urban farming arise out of necessity. Technology development becomes dependent on science in China, India and Brazil.

For each scenario an innovation pathway or a cluster of innovations related to consumer, product and circular is developed.

Innovation pathway high tech

Pathway: fully convenient concept

Targeting the consumer group that is highly convenient-oriented and has a need for processed fruit and vegetable products. These convenience products which are easy available, easy to prepare and easy to eat support consumer to increase consumption in different consumption moments during the day in and out of home. Due to a high control of the chain, its quality and produce quality loss and waste of fresh fruits and vegetables is avoided and transformed into convenient, processed products. In this case, one could think of pre-cut fresh products that are processed to ensure a good taste, long shelf life, and reduced cooking time. Other elements in this pathway are more processed food with traditional shapes and taste but adjusted composition such as hybrid products (partly plant-based).

Pathway: Targeting communication – personalized nutrition

Targeting groups of people and knowing their personal preferences and wishes will become more and more important and will in some cases even be to the individual level the so-called personalized products. Not only the product itself but also the package and information on the package is important. Some consumers might for example be interested in specific nutrients or specific aspects of sustainability. Providing information about F&V health perception towards specific target groups. In this case, one could also think about branding with certain brands aiming at different groups of consumers. Some brands already exist for fresh fruits and vegetables, for example aimed at high quality or excellent taste. This could perhaps be expanded with brands aiming at other motives such as health aspects, sustainability, etc.

Innovation pathway self-organisation

Pathway: Internet of fruits and vegetables

Offering high quality to demanding consumers the online sales of fresh products such as fruits and vegetables and delivery will change the food logistical system and support consumers. Delivery of these fresh products shows a need for an appropriate package size especially for those people who will not do any traditional shopping anymore. Similarly, storage of might include more digital aspects such as smart fridges and shelf-life innovations. These innovations can facilitate consumers to reduce their food waste, for example

through fridges, chips in packages, and apps, consumer are supported to consume foods before they are wasted. Another element in this pathway may be apps that facilitate fruits and vegetables (products) that contain a higher level of specific nutrients.

Pathway: Country of origin - from tropical to local

Increasing local consumption of local production instead of tropical might be an option for the more green or conscious consumers, who are aware of the influence of transport on sustainability. This is especially the case for fruits. But also vegetables: for example local seasonal vegies instead of imported or greenhouse vegies. These green consumers might be motivated to eat local fruit but they might be not aware of the season of when to get specific fruits such as berries. Those people who are motivated should be facilitated with information by means of food miles, apps or information on package of country of origin.

Innovation pathway collapse

Pathway: empowerment of fruit and vegetable consumer

To empower consumer in a fast changing world with lots of challenges support will be given about regional and urban farming of local fruits and vegetables. Taking part in the production raises awareness of consumers and will increase their involvement. Since consumers are much closer to production in this case less fruits and vegetables will be wasted. To avoid waste, consumers will have a need for support of experts in this process of learning by doing. In this case, one could also think about information about how to use (parts of) products with a lower quality in specific parts of the meal, home-grown fruits and vegetables, and products that do not comply with the regular quality standards such as different-shaped products.

Pathway: Increase awareness – possibilities of portions

To overcome the challenges partly caused by western diet shows the need for a more plant based instead of animal based diet. Targeting all consumers who eat fruit and vegetables below recommendations and whose intake of animal-based product is above recommended levels. Generally, these consumers overestimate their own fruit and vegetable consumption and are unaware that their consumption of animal-based products is too high. Different ways to raise awareness can be applied not only by means of informing them but also by selling portions which tell consumers that consumption of that portions is in accordance with daily recommendations. So for example in ready-to-eat meals with the right amounts of vegies in the dish, or by providing measuring tools. In addition to this raising awareness is not only about consumption but also about

wasting fruits and vegetables, by means of supporting planning, buying and consumption. For specific groups of consumers targeted information might be helpful, for example related to the person's stage of change.

These innovations pathways are some examples which show different possible opportunities to stimulate fruits and or vegetable consumption. It shows that innovation pathways should be the right combination of consumer, product and circular innovations in the right context. This implies that there are uncountable opportunities but it is all about the right combinations of the right target group, right fruit and vegetable products in a specific social and physical context taking not only the consumed product into consideration but also the full production and processing chain in order to avoid waste. In addition, it shows that these pathways imply both incremental innovations as well as more radical innovations.

5. Discussion and Conclusion

5.1 Reflection

When formulating and reflecting on the innovation pathways there are several interesting issues we want to share in this chapter. We will address issues related to consumer, fruits and vegetables, process, content and circularity. These issues are open for discussion and prioritisation in final stage and open workshop of SUSFANS.

- There is a huge amount of possible combinations of innovations which should be brought together and show the need for the right combinations in order to reach the right consumer with the right product under the specific circumstances in the right condition.
- There is a broad range of drivers influencing consumer acceptance of innovations. The presented innovation strategies and pathways show the need for a multifaceted approach. Ideal innovations or innovation pathways should consider both consumers, product and processing as well as context and how to deal with waste or rest streams. While in practice there could be also innovations only considering product and consumer or consumer and process.
- All issues related to consumer show that it might be hard to reach consumers while their food choice is just one of their daily life activities which needs attention thus it doesn't have consumers priority as we would like it to be. It is more than targeting and changing diet but also issues related to consumers' mind-set such as culture, involvement, intentions attitudes should be taken into consideration. More radical or cultural changes in eating habits might be needed to raise consumption levels to the recommended levels since traditions with regard to food consumption and it's culture needs to be changed.
- Pathways can be directed towards fruits and vegetables in general or specifically for fruits or for vegetables. Whereas in general similar strategies are relevant, there are some crucial differences between fruits and vegetables in terms of intake, usage, moments, consumer preferences, processing, and to some degree also health and sustainability.
- The innovation pathways are put into the perspective of three scenarios, possibly one or more scenarios need to be added. Innovation pathways based on a set of innovations need to be identified and scaled under

contextual change (culture, economic, policy) and the indirect drivers of consumer behaviour such as megatrends, shift in demographic profile of the population, etc. To be checked if these scenarios are there next to each other and which scenario is expected to have more or less impact?

5.2 Link of innovation pathways with models, toolbox and issues for future research

Changes in fruit intake, vegetable intake and fruit & vegetable intake are relevant also for the computational and assessment models used in the SUSFANS toolbox. However, transformation of the evidence on consumer drivers towards the models is complicated due to large amount of determinants influencing consumption, and the complexity of their interplay. Especially since these determinants, with the exception of price responsiveness and preference or taste, are not included in the current models and for some of the models, the household level is used rather than the individual level. The outcomes of this study can therefore not directly be translated to the models. This is in contrast to Deliverable 5.2 where the production perspective can be directly translated to MAGNET, GLOBIOM and CAPRI.

There are however, routes that could be explored to make this connection in the future. One possible way is to incorporate some of the main determinants in the existing models. This would require a discussion on the choice of determinants in relation to the conceptual underpinning of the models. In order for choice determinants to be productively incorporated into a system of equations on food system relations, the determinants must be made responsive to one or more variables in the food system models. At present, the scope of the SUSFANS toolbox is limited as the physical environment (expect price) and interpersonal environment are not modelled. Some critical points here are the earlier mentioned many and interrelated determinants. In addition, there is the technical feasibility of incorporating the determinants in the models, and the fact that the models have their own limitations in terms of short and long term, small and big changes, ability to model changes at the systems level.

Another route might be to make the connection through the common factor in both: the diet. The SHARP model and the model developed by INRA (see Deliverable 1.4 and 9.1) are based on the diet or food consumption in the case of the SHARP model and scanner data of food purchases in the case of the INRA model. If the connection could be made between determinants and specific

food products of product categories these categories can be used to link to the models. To give a very simplified example that ignores the interplay between determinants and the different aspects and degrees of convenience orientations: People who are more convenience orientated might eat more pre-cut vegetables, so then if we see a high (increase in the) intake of pre-cut vegetables this means more convenience-oriented consumers.

Finally, the consumer orientation could be introduced in the modelling by means of scenario assumptions rather than model dynamics. There is a wide body of applications from assessment models that develop diet scenarios on hypothetical changes in consumer diets in order to explore the impact and trade-offs of diet change on the food system. Typically such studies are rooted into an economic representation of demand (Valin et al. 2013), but to our knowledge there is no single scenario application in any of the leading global model framework that has been properly underpinned with consumer research. A particular option that will be explored in SUSFANS is whether a scenario on changing consumer choice could be better underpinned by applying the SHARP model or a nutrient profiling model. The added value in terms of nutritional consistency of future diet scenarios for a particular population might also provide a bridge for introducing evidence on consumer choice on the feasibility of, and options for moving towards such hypothetical diets.

Several issues should be considered when exploring these and other ways to link determinants of consumer behaviour to the SUSFANS model:

- The impact of increased intake on health and on sustainability – when increasing intake of fruits and vegetables it is not considered if this will be additional to the diet or if there will be substitution effects in the diet like for example substitution of animal based foods, energy dense foods, or will the diet be more plant based than the current diet. Further research is needed to study if increasing fruits and vegetable intake might increase health status but not necessarily results in more sustainable diet. This depends of if less of other animal sources or energy dense foods consumption is lowered or not. Different trends and scenario's should be calculated.
- The approach through products and product groups (fruit and vegetables in this paper; animal source food in report 5.2) is not in line with the fact that in terms of health the diet as a whole including several product groups is of importance rather than specific foods.

- The complexity of the consumer, the interplay between determinants and the different aspects and degrees of their motives, and their different reactions to changes will have to be simplified to consumer profiles in order to fit into the models. This is in sharp contrast with developments in consumer research that take this complexity into account. In the current models, consumers are often defined in terms of demographics, income, age, BMI. There is a lot to gain by including determinants from the consumer perspective but for a consumer researcher the question remains how useful this is when we have to work with very simplified representations of the consumers. Recognition is given however, of the powerful simplicity of future projections of consumer food demand, and the direct need for a better underpinning of such analyses.
- As mentioned before, taking the consumer and innovations in consumer behaviour as a starting point is very different from taking the production innovations as a starting point and the consumer reaction as a consequence of this. This deliverable aimed to provide a starting point and inspiration for discussion to bring these two perspectives more in line.

5.3 Issues to consider and limitations:

- **Environmental and nutritional Impact**: The described innovations are supposed to increase fruit and vegetable intake and therefore have a positive impact on health. The impact on sustainability however is not that straight forward but should be represented in indicators such as emissions with impact on greenhouse gas, land use, air, soil and water quality and finally its influence on global warming. On the other hand, circular strategies such as rest streams and lower food waste impact sustainability and not necessarily linked to health.
- **The differences between countries** is not taken into account. Countries within the EU differ in the consumption levels of fruits and vegetables in general as well as specific products. Also, the drivers behind behaviour might differ between countries. For example in SUSFANS deliverable 2.1 differences were found between countries in consumer perceptions of sustainable food (Bouwman et al., 2017).
- The current **position of F&V in the diet** of people compared to other product groups should be considered. But also fruits have a different position in the diet than vegetables, they are consumed in different

moments. Next to that, the meaning to specific nutrients like vitamins or fibres in fruits and vegetables differ from that of for example protein in meat. And, finally, fruits and vegetable product chains are often short compared to other products which might have implications on for example consumer perspectives on product.

- There is the **time-perspective of breeding**: different elements of the breeding, production and processing of fruits and vegetables, some characteristics cannot be improved in a short time.
- We should be **careful when considering the influence of improving knowledge and stimulating education** as the route to follow. This might be a solution for a specific group of consumers who is already more conscious. Generally consumers know that fruits and vegies are healthy, but this doesn't make them eat enough, thus other pathways might be more successful for the less interested consumer.
- **Differences between 5.2 and 5.3**. In deliverable 5.2 it was aimed to decrease consumption this is a different issues compared to increasing consumption. Also, the starting point was the consumer perspective with has different outcomes than taking innovations in the production as a starting point and consumer reaction as a consequence.

5.4 Conclusions

In order to develop successful innovation pathways there should be attention for the right combination of targeting consumers, product, context and or communication and circularity. The identified innovation strategies are multifaceted related to consumer, fruits and vegetables together or separately, contextual and or circular. Theory about consumer insights and examples of innovations strategies and pathways are provided for the case of fruits and vegetables. Further exploration and discussion is needed to support the consumer perspective in innovations and link this to foresights, research and or modelling.

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