Will Novel Protein Foods beat meat?

Consumer acceptance of meat substitutes - a multidisciplinary research approach

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Thesis

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ABSTRACT

Meat production places a heavy burden on the environment and therefore options are sought to reduce meat consumption. One option is to let new meat substitutes take the place of meat on the plate. This can only succeed when these products are acceptable to consumers. This thesis investigated which factors are involved in consumer acceptance of meat substitutes to reduce the consumption of meat.

Looking back in time, it becomes apparent that in development and acceptance of food substitutes, like margarine and sugar substitutes, different factors played a role. Technology advances and governmental policy measures could create favourable preconditions but the degree of replacement ultimately depended on consumer acceptance. This required a product quality comparable to the original products and a fit with consumer needs. The process of substitution generally takes many years, both from consumer acceptance and from product development point of view.

First of all, consumers need to have a reason to choose for meat substitutes instead of meat. Therefore, drivers and barriers to use meat substitutes were identified by two surveys. Opposed to the ethical motives of heavy-users of meat substitutes (mainly vegetarians), non-users and light/medium-users were primarily focussed on the sensory and familiarity aspects of foods. These aspects were not at all recognized in meat substitutes by these consumers. Meat was judged more positively overall, which explains the choice for meat. In addition, food neophobia (the tendency to avoid new foods) was a large barrier for initial trial and a meat-like meat substitute was preferred to begin with.

Secondly, the identification of a product as an alternative to meat is important. A categorization study showed that consumer perceptions are largely influenced by a deep-rooted taxonomic classification of meat (e.g. beef, pork). In order to be considered as an alternative to meat, a certain degree of similarity is needed. Meat substitutes were grouped together with processed meats (like sausages) due to a similar appearance and similar application in meals, but not with unprocessed meats. New concepts that were radically different from meat in appearance were not at all recognized as alternatives

In the third place, meat substitutes need to result in a comparable product experience as meat, such as satiety feelings after eating. The protein content is an important factor in satiety. A product inventory indicated that the majority of meat substitutes has a lower protein content than meat. In a consumption study it was shown that meat substitutes high in protein were able to induce stronger feelings of satiety, even more than the meat reference products. However, meat substitutes with a low protein content were less satiating.

Finally, it should be possible to eat meat substitutes regularly without getting bored. A repeated consumption test was performed with two meat substitutes and a meat reference. It was found that initially the meat reference was liked most but after 20 exposures the difference in liking disappeared. Both boredom and increased liking of products were observed. Strikingly, there were more persons with an increased liking for the meat substitute dissimilar to meat (tofu). This is in line with the mere exposure effect implicating that unfamiliar products are liked better over time.

In conclusion, meat is obviously anchored in our culinary culture and it will take time to change this. The use of substitutes introduces specific challenges due to a direct comparison and competition with meat. Meat substitutes need to offer additional benefits, which is not yet the case for the majority of consumers. At present, it seems too early for radically new protein products, since a certain level of similarity to meat is essential. Improvement of the sensory appeal of meat substitutes needs to be continued and it is worthwhile to explore other options further, like combined plant/meat protein products.

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Chapter 1

General introduction

1.1 THE NEED FOR FOOD SUBSTITUTES

In the modernized world, food has evolved from a basic physiological necessity to a luxury pleasure item with social-cultural significance. With that, the quantity of food has grown from shortage to abundance. These quantities of food that are now being produced, processed, distributed, and consumed, have a huge impact on our society, both on population health and on the environment (Duchin, 2005; Grigg, 1995; McMichael, Powles, Butler, & Uauy, 2007). The rising prevalence of overweight and obesity, which relates to the quantity and composition of foods we choose to eat, is clearly noticeable (European Commission, 2007; Haslam & James, 2005; WHO, 2003; WHO, 2006). Probably less obvious for the average consumer are the costs of the increased food production, which requires land, water, fertilizers, energy, and results in increased emissions and environmental pollution (e.g. Pimentel & Pimentel, 2003; McMichael et al., 2007; Tilman, Cassman, Matson, Naylor, & Polasky, 2002). In fact, the consumption of foods has the largest total effect on the environment (estimated 20-30%), of all the activities consumers are undertaking in and around their homes, such as transport and energy use (Tukker & Jansen, 2006). Therefore, the impact on how we live and eat on our own health, and the health of our environment, gained considerable attention recently. It is felt that something needs to change. However, the sense that something must happen usually does not start off with consumers themselves. Initiators are mostly governmental bodies and NGO's involved with health and environmental issues (e.g. Aiking, De Boer, & Vereijken, 2006; Dietz, Benken, & Hunter, 2009; Vijver, 2005; Foster & Lunn, 2007; Sanne, 2002; Swinburn, Gill, & Kumanyika, 2005).

One approach that can be taken is to try to *change the behaviour of consumers directly*. Promoting a healthy lifestyle and food choice by communication campaigns and intervention programs on behaviour seem to be challenging and the effects of these interventions vary (see reviews of Cavill & Bauman, 2004; Hardeman, Griffin, Johnston, Kinmonth, & Wareham, 2000; Glenny, O'Meara, Melville, Sheldon, & Wilson, 1997). Similar challenges are faced by efforts to promote more environmentally friendly lifestyles (e.g. Jackson, 2004; Lorenzoni, Nicholson-Coleb, & Whitmarsh, 2007; Tanner, 1999). Another interesting route is not to try to change the behaviour directly but *to replace current food products* (e.g. high calorie foods, environmentally unfriendly foods) *by substitutes* that have been improved on these aspects (e.g. food products with less calories, or less impact on the environment). These food substitutes are meant to take the place of the originally used products in consumers' diets without requiring a radical change in eating behaviour. The latter route is explored further in this thesis in order to reduce the environmental impact of food consumption.

1.2 THE CASE: SUSTAINABLE SUBSTITUTES FOR MEAT

Of all foods, meat comes promptly in the picture when considering the sustainability[1] of food production. A meat-based diet requires a significantly greater amount of environmental resources per calorie compared to a more grain-based diet. The production of animal proteins is namely inefficient: 2 to 15 kg plant foods are needed to produce 1 kg of meat (Aiking et al., 2006; Tilman et al., 2002; McMichael et al., 2007; Pimentel & Pimentel, 2003). Suppose that we would eat those plant foods directly. In that case, the intermediate conversion step of meat would be omitted and only a fraction of the resources would be needed for production. This was the basic philosophy behind the research program PROFETAS, of which the research project described in thesis belonged to. The acronym stands for Protein Foods Environment Technology And Society (Aiking et al., 2006; Jongen & Meerdink, 2001). The overall research program studied the options for new food substitutes, so called Novel Protein Foods, to reduce the consumption of meat. Novel Protein Foods are protein rich foods produced by a new or extensively modified process from plants or micro organisms (Jongen & Meerdink, 2001). Evaluating the feasibility of such a scenario requires a multidisciplinary approach, including the environmental and technological aspects. These issues are described elsewhere (Aiking et al., 2006). The basic assumptions of the PROFETAS program that were of influence on the approach of the studies in this thesis were:

- Novel Protein Foods are meant as an alternative source of proteins in meals. Explorative studies indicated that this application offers the greatest environmental impact and technological possibilities (Aiking et al., 2006).
- The target population is the Western European population due to the sustainability of local production and transport.
- Novel Protein Foods[2] are primarily aimed at meat consumers and not vegetarians. After all, these meat substitutes are intended to reduce the consumption of meat, which is already done by vegetarians/vegans.

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[1] The general statement by the World Commission on Environment and Development (Brundtland, 1987) is often used as a definition of sustainability: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. It links the environment's ability to meet present and future human needs as a basis for ecological, economic and social aspects of sustainability (Langhelle, 2000). In this thesis, sustainability refers only to the environmentally aspect.

[2] Throughout this thesis, the term meat substitutes generally refers to the overall category and current products on the market, while Novel Protein Foods refer to new products that need to be developed still. Novel Protein Foods are thus specific examples of meat substitutes.

1.3 WHERE DOES 'THE CONSUMER' ENTER THE STORY?

The ambition is thus to make meat consumers eat less meat by means of a substitute. This is not an easy task. Meat has traditionally held a central position in Western food culture (Fiddes, 1991; Meiselman, 2000), and it obviously still has. Douglas & Nicod (1974) illustrated that meat is the centre of meals: it even assigns the name to a dish. In addition, with increasing wealth and incomes it is expected that meat consumption will increase even further (Tilman et al., 2002). Obviously, meat consumers are quite satisfied with this attractive product (Issanchou, 1996; Grunert, 2006) and most likely they do not actually feel the need to choose otherwise.

Are consumer needs relevant for developing successful new food products? In general, food innovations can arise in different ways. On the extreme ends are market / demand pull and technology / science push. In a market pull or demand pull situation, an innovation starts with an expressed need in the market upon which a product is being developed. Market pull takes consumers as a starting point. This is in contrast to technology or science push that starts with a specified technology and implies a push of the product on the market. The product is then rather based on technology advancements than on an identified consumer need. Developing new products exclusively based on technology or science push development is therefore considered to be more difficult and challenging (e.g. Bishop & Magleby, 2004; Rothwell, 1994; Van Kleef, 2006; Van Trijp & Meulenberg, 1996).

The scenario we are dealing with here, developing Novel Protein Foods for environmental reasons, is more a third type of food innovation which could be considered an 'environment push' (MAF, 1997). It does not start with a new technology or science, neither is there an *explicit* need from meat consumers. Government or NGO's started this development with investing in research and development as well as public investments in small businesses (Aiking et al., 2006; Dutch Ministry of Agriculture, Nature and Food Quality, 2009). Taylor (2008) described a similar case for emerging solar energy technologies and how upstream investment by government actions led to environmental innovations. This type of innovation is more complex, and involves diverse actions by a number of actors along the innovation chain to fulfil government objectives. However, in any of these three routes to innovation, market success depends on a very import actor, namely the consumer. Understanding consumer needs and reacting effectively to them is one of the most important factors in product development success (e.g. Cooper & Kleinschmidt, 1994; Stewart-Knox & Mitchell, 2003; Urban & Hauser, 1993; Van Kleef, 2006). A new product should aim at the fulfilment of consumer needs and the realisation of consumer value, and not focus on technology or product development per se. We should gain an understanding of consumer needs in order to incorporate this into product development, which

finally results in a product quality that is desired by consumers. This implicates that consumer needs and perceptions need to be identified from the beginning of the development process (e.g. Costa, 2003; Urban & Hauser, 1993; Van Kleef, 2006; Van Trijp & Steenkamp, 1998). So regardless of the 'environment push', this also holds for new meat substitute products such as Novel Protein Foods. In addition, there are two other specific points of attention in the case of Novel Protein Foods: it deals with *substitution* and with consumer acceptance of a *food* product.

1.4 CONSUMER BEHAVIOUR AND SUBSTITUTION

The numerous aspects that might play a role on consumer behaviour and ultimate choice for a food substitute can be structured by different stages in consumer decision making. Several models describe this process (e.g. Howard & Sheth, 1969; Engel, Blackwell, & Miniard, 1986). Essentially these types of models illustrate that it is not only about the buying or consumption moment itself, but that it starts before that stage and continues even after the purchase. This can for example be illustrated by the seven stages model of Blackwell, Miniard, & Engel (2006):

1. Problem recognition or need. This deals with the *Why* behind the behaviour, which can have a physiological and/or psychological basis. There must be a reason for buying a substitute product (e.g. a motive or attitude to eat a food that considers animal welfare).
2. Search. This involves the search for internal (e.g. experiences) and external information (e.g. package information that communicates animal-friendly).
3. Evaluation of alternatives (e.g. meat substitutes, organic meat, fish). In this step the most suitable alternative that satisfies consumers' need is determined. Alternatives are evaluated on a limited number of choice criteria (e.g. not from animal source, needs to taste good). The aspects that are considered and the relative importance attached to them, depends on the available alternatives and consumer characteristics, such as personality and underlying motivations.
4. Purchase. Making the final selection and paying for it (e.g. a meat substitute from the supermarket).
5. Consumption. The product is consumed for the purpose of fulfilling the need (e.g. have something tasty for dinner which is enjoyed by the whole family).
6. Post-Consumption evaluation. The satisfaction with the purchase and consumption is evaluated (e.g. it had no meat and it did taste great) which might lead to a repeat purchase.
7. Disposal of product and packaging.

It would be unrealistic to assume that for every single purchase consumers would go through such a detailed process, but the model can be used as a framework for the relevant factors in research (Van Trijp & Meulenberg, 1996).

In the previous section, the role of consumer needs was discussed. When we now zoom in on stage 2 and 3, it becomes apparent that a substitute product is not considered in isolation, but perceived and evaluated in relation to other products (e.g. Antonides & Van Raaij, 1998; Shocker, Bayus, & Kim, 2004). Especially in the case of new products, consumers make use of information and experiences with reference products (Gregan-Paxton, 2001; Michaut, 2004; Van Trijp & Van Kleef, 2008). Meat substitutes are therefore most likely compared to meat. In addition, not all available products are considered in the evaluation and choice between alternatives (stage 3). When consumers are exposed to a large number of alternative products, they first screen the initial set of alternatives down to a much smaller set of relevant products which is called the consideration set. Subsequently, the product of preference is chosen from that set (e.g. Antonides & Van Raaij, 1998; Nedungadi, 1990; Ratneshwar & Shocker, 1991). It is essential for Novel Protein Foods to qualify for these stages in order to be chosen by consumers.

Shocker et al. (2004) have described the acceptance of substitutes and the role of 'other products' in more detail. Substitutes are specified as substitutes-in-use, which are products that serve a similar purpose and have similar potential customers, as is the case for meat and meat substitutes. Substitutes are also differentiated from complements. Complements are products that can be used next to each other, and which have little value when they are used separately (e.g. a computer and software). It is important to distinguish substitutes from complements. After all, it probably does not matter from a sales perspective whether meat substitutes are used as a supplement to a dish with meat, but from the environmental perspective it is important that meat is actually being substituted.

Furthermore, a static situation is differentiated from a dynamic situation. A dynamic situation exists when there are changes in the frequency and way of use of the substitute in relation to the reference product. This occurs when there is a different order in product entry of the market. The category or product that already existed serves as a context for decision making and the appreciation of the new product. When new types of meat substitutes, like Novel Protein Foods, enter the market this will at first be a dynamic situation. Consumer perceptions and decisions on new meat substitutes will thus be influenced by products already on the market, such as meat or other meat substitute products. A dynamic situation can develop over time into situations of product perseverance to product displacement. On the one extreme hand there is product perseverance which occurs when the newcomer fails to replace the older one (e.g. the scenario that Novel Protein Foods disappear from the market).

Failure to meet customer needs adequately is a frequently cited reason. On the other extreme end is product displacement. This is when new and improved categories or products come to dominate older ones and eventually make them obsolete. In that case the newer product offers a higher level of all core benefits than the reference product (e.g. the scenario that Novel Protein Foods would completely replace meat) (Shocker et al., 2004; Wansink, 1994).

Thus, for understanding consumer needs and perceptions of a meat substitute, the position towards the reference product meat needs to be taken into account. After all, the product (either meat or a meat substitute) that offers the highest value to the person will ultimately be preferred. In addition, consumer behaviour with respect to meat or meat substitutes needs to be considered along the different stages in consumer decision making; from consumer needs to consumer evaluation after consumption. Due to the environmental aim of Novel Protein Foods, it is also important that actual substitution of meat takes place, rather than being used as a complementary product. This will be a dynamic situation when Novel Protein Foods enter the market, and therefore changes over time need to be considered as well.

1.5 FACTORS IN FOOD CHOICE AND ACCEPTANCE

Consumer behaviour with respect to foods requires further specification. Food products are often referred to as specific types of consumer products, due to the high frequency of use by consumers - daily, the physiological function, the actual ingestion of the product, the role of taste, and cultural meaning (Booth, 1994; Jaeger 2006; Meiselman, 2000; Rozin, 1999). In order to understand consumer choices for certain foods and ultimate food acceptance, a large number of models or theoretical frameworks have been published from different disciplines (e.g. food sciences, nutrition, psychology, consumer behaviour, and marketing). Obviously, eating and drinking cannot be explained by hunger and thirst only. Food choice is influenced by several factors: such as sensory, physiological, and social factors (Meiselman, 2008; Mela, 1999). In an overview of different food choice models (Shepherd, 1989), most of these models appear to have a similar arrangement in factors related *to the food, the person and the environment*. The food choice model of Shepherd (1989) is used as an illustration (Figure 1.1).

A food product is a complex combination of ingredients, which can be described via sensory properties, such as the appearance, taste, odour, and texture of the food. These sensory properties influence how consumers experience a food product. In interaction with the food, for example while eating, the food senses are stimulated which elicits certain sensations or feelings (e.g. a bitter taste, a pleasant feeling)

(Schifferstein & Hekkert, 2008). The physical/chemical properties and nutrient content lead also to certain physiological effects after consumption, like satiety feelings, that influence subsequent choice and intake of a food product. The food choice model in fact needs to be complemented with the different types of attributes that play a role in the purchase and consumption of a food product (see also the different stages in consumer decision making discussed in the previous section). Search attributes (e.g. the appearance of a meat substitute) can be evaluated before the purchase, experience attributes (e.g. the taste of a meat substitute) can only be evaluated after the purchase, while credence attributes (e.g. environmentally friendly) are a matter of consumer trust and cannot directly be evaluated (e.g. Issanchou, 1996; Grunert, Bredahl, & Brunsø; 2004; Van Trijp & Steenkamp, 1998).

How a food product is perceived and experienced also depends on the person. There are psychological differences between persons (e.g. personality traits), differences in lifestyle, levels of education and knowledge, which influence the attitude towards certain food products. A particular personal characteristic, called food neophobia, and the relation to the acceptance of foods has gained a lot of attention over the past years (e.g. Pliner & Hobden, 1992; Pliner & Pelchat, 1991). Food neophobia, which means the fear for novel foods, probably originates from the early days in which the avoidance of unknown foods was crucial as these foods might be poisonous or otherwise harmful (e.g. spoiled meat or dangerous mushrooms). In case of new food products, such as Novel Protein foods, this might be of particular importance (Van Trijp & Van Kleef, 2008).

External or environmental factors to both the individual and the food are the social and cultural environment, which will have an impact on food choice. There are cultural differences and norms that may require certain dietary guidelines, like avoiding meat for religious reasons. Other external factors include: availability, price and packaging (Shepherd, 1989). Besides this broad context, there has been a call for attention to include the situational context in which foods are eaten (Jaeger, 2006; King, Meiselman, Hottenstein, Work, & Cronk, 2007; Meiselman 2000; Meiselman, 1992). In experimental settings, it has been shown that there is an effect of the situation on the acceptance of foods. Edwards, Meiselman, Edwards, & Lesher (2003) showed that the location contributes significantly to food acceptance. For instance, foods served in an institution are liked less than the same foods consumed in non-institutional settings. Another type of context in which the product is embedded, is the meal context. Foods are usually eaten in combination with other foods (Meiselman, 2000). The importance of this was demonstrated by Marshall & Bell (2003) who found that food choices were more strongly associated with specific meals than they were with specific locations. However, context effects need more clarification still since the effects of context

variables, like the physical environment, may vary between different meals and across meal components (King et al., 2007).

The time factor is also of importance and should be complemented to the food choice model. Food acceptance in general is not considered to be static. Consumers can change their opinions about a food product after repeated consumption to the same food product over longer periods of time (e.g. Chung & Vickers, 2007; Pliner, 1982; Schutz & Pilgrim, 1958; Siegel & Pilgrim, 1958). This can result in an increase in liking (called mere exposure) or a decrease in liking due to boredom or product irritation (as reviewed by Zandstra, Weegels, Van Spronsen, & Klerk, 2004). Thus, in studying consumer acceptance of food products such as Novel Protein Foods it is important to not only consider the food product itself, but also the influence and interaction with the person, the environment and changes over time.

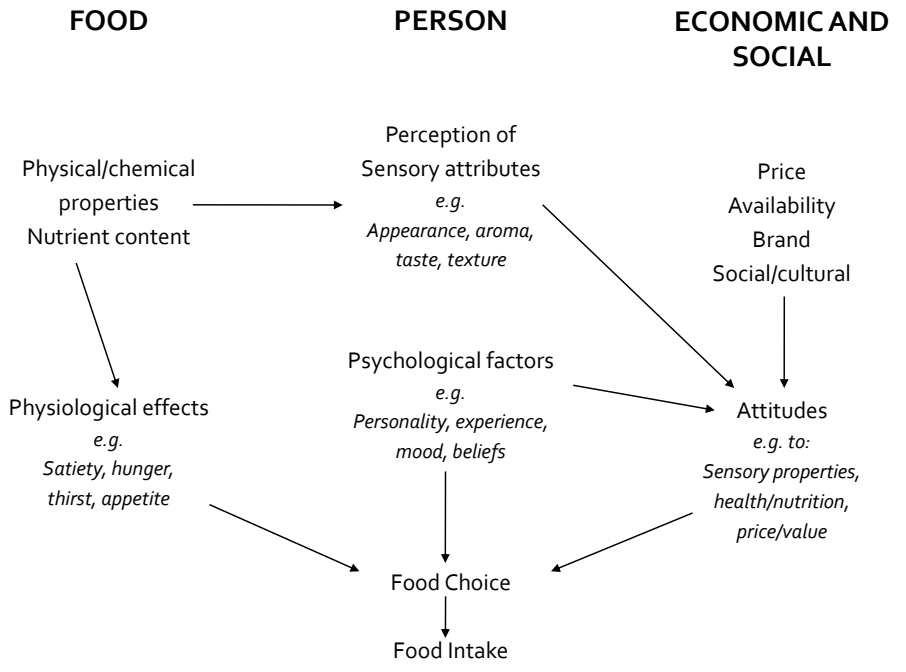


Figure 1.1: Food choice model according to Shepherd (1989)

1.6 SCOPE AND AIM OF THIS THESIS

The success of Novel Protein Foods as new sustainable meat substitutes will ultimately depend on consumer acceptance. The research described in this thesis therefore

focussed on the consumer side of the PROFETAS story. The overall research program PROFETAS was not meant as a product development project but for development and evaluation of potential directions for Novel Protein Foods. However, this phase can be compared to the very beginning of the NPD (new product development) process referred to as opportunity identification (Urban & Hauser, 1993), for which 'the consumer' is taken as a starting point. In this phase, the main focus for consumer research is understanding the consumer needs, product perceptions and experiences, which serves as an input for later phases, i.e. product design and product positioning.

The points of departure for this research are in line with the PROFETAS assumptions (see section 1.2). In addition, current meat substitutes were used as test products since there were no Novel Protein Foods products or concepts available at the time of the research. It is also important to stress that, although the overall PROFETAS project aims to reduce the environmental pressure, environmental consumer motives were *not* taken as a starting point. The focus was on existing consumer needs and perceptions, whether this would be for health reasons, environmental reasons, taste or price, etc. What matters most is that meat consumption is replaced by consumption of meat substitutes, irrespectively of the underlying motive.

The overall research question is:

Which factors play a role in consumer acceptance of meat substitutes to replace the consumption of meat?

The research approach is a multidisciplinary approach that includes the previously described essentials of consumer behaviour, substitution, and food choice acceptance research. The research assumptions are:

- The consumer perception and acceptance of a food substitute needs to be studied in relation to the reference product. In this case thus meat substitutes and meat, which is the reference.
- The different factors in food choice and their interactions need to be considered: the person, the product and the context.
- Food acceptance and substitution by new products is not static and needs to be considered over time.
- The different 'stages' in consumer choice and consumption must be taken into account, so from consumer needs, product identification, consumption experiences, to repeated consumption.

So instead of an in-depth investigation on one single aspect in consumer acceptance, the approach was to answer the research question by using different disciplines (e.g. psychology, sensory, physiology). Note that the sensory aspects and the context of the meal are also of great importance for acceptance of Novel Protein Foods. However, these were investigated in greater detail by another PhD project and therefore not described in this thesis (see Elzerman, 2006).

The content of this thesis is as follows (shown schematically in Table 1.1):

Chapter 2 — In this chapter, the development and acceptance of different food substitutes *in the economical/social context* is considered. A working definition of food substitutes is formulated and a distinction between different types of food substitutes is made. By taking a retrospective view on some food substitute cases, like margarine replacing butter, the role of technological advances, governmental policies, and consumer acceptance on the final degree of replacement by food substitutes is discussed.

Chapter 3 — The 'why' behind the acceptance of meat or meat substitutes is explored by investigating *consumer characteristics and motives.* Two consumer surveys illustrate how general person-related factors, such as lifestyle, food choice motives, and food neophobia, and specific attitudes and beliefs towards meat and meat substitutes, may act as drivers and barriers in acceptance. Meat substitutes are not considered in isolation but consequently compared to the position of meat. How these two different products fit with consumer interests is evaluated.

Chapter 4 — The *identification of meat substitutes* and meat is described by means of the categorization theory. This chapter investigates how and on what basis non-vegetarian consumers perceive and categorize both types of products. This is in line with the real situation on the market: meat as a category is already present, and consumers are faced with meat substitutes that enter after that. New concepts of Novel Protein Foods, that are radically different in appearance from meat, are included in the study as well.

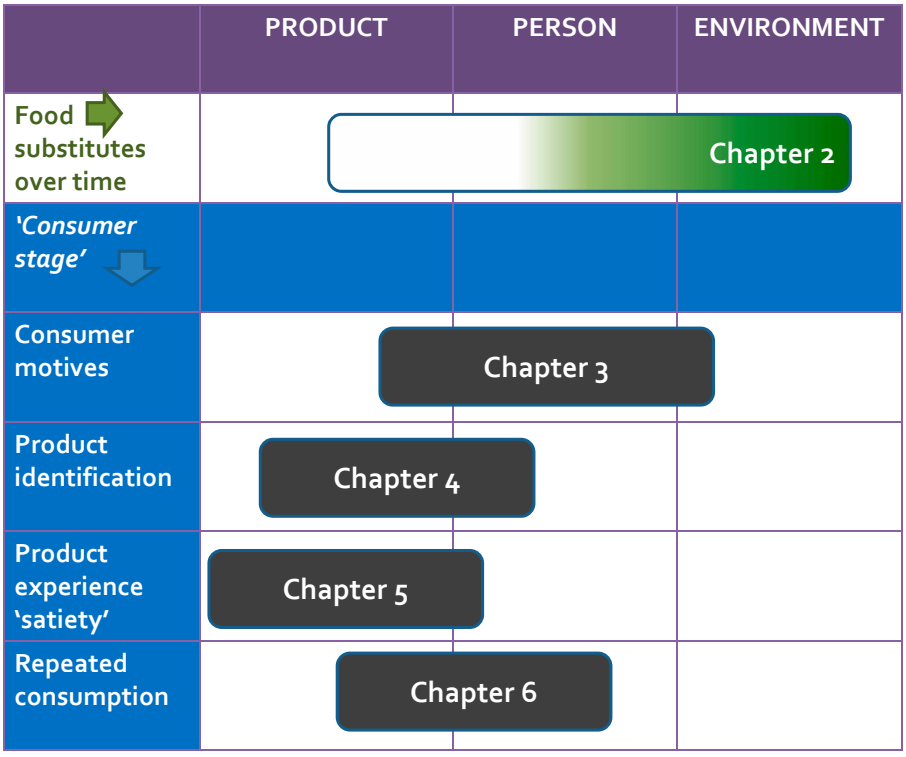
Chapter 5 — This chapter deals with the *physiological effects*, namely satiety, as part of the product experience after eating meat substitutes. Firstly, a product inventory is performed which illustrates how meat substitutes currently on the market differ from meat with respect to key satiety components. Secondly, the effect on satiety feelings is illustrated and discussed by a consumption experiment with meat and meat substitutes.

Chapter 6 — This chapter investigates *the dynamics in liking over time* of meat substitutes and a meat reference by a *repeated consumption* study. This is based on the question whether meat substitutes, either similar or dissimilar to the reference meat product, are accepted better over time or whether consumers get bored with

it. This is especially of relevance since Novel Protein Foods need to be eaten on a regular basis for a long period of time.

Chapter 7 — The research findings are summarized and discussed with respect to the implications of 'the consumer side of the story' for development and promotion of Novel Protein Foods to decrease meat consumption. The discussion includes the limitations of the approach and suggestions for further research.

Table 1.1: Overview of the chapters in this thesis



The position of the bars indicate the main factors under attention in that chapter: the product, the person or the environment.
'Consumer stage' refers to a specific aspect in consumer choice or consumption.
To reduce the complexity of the table, the meal context is now listed at the factor 'product,' and economical/social context and time are listed at the factor 'environment'.

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Chapter 2

Food substitutes: a retrospective view on the roles of food technology, governmental policy, and the consumer in development and acceptance over time

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ABSTRACT

For the development of new food substitutes, like meat substitutes, it is of interest to learn which factors played a role on the development and acceptance of previous food substitutes. We therefore looked back in time and considered different types of food substitutes from the time period 1870 to 2000 in the Netherlands. Food substitute cases were - in order of success: margarine (replacing butter), sugar substitutes (replacing sugar), breakfast drink (replacing breakfast), texturized vegetable protein TVP (replacing meat), and fat substitutes (replacing fat). We discuss these food substitute cases in the context of technological advances, governmental policy measures, and consumer needs and trends during the times they were developed. It seems that all factors positively influenced the food substitute margarine, which probably explains it success. Generally, the factors acting on the illustrated food substitutes were very different and interacting, and it is therefore not possible to point towards a single factor. We therefore discriminated preconditions from essential factors. Both large technological advances and governmental support can positively influence the development of food substitutes, but are not essential (as illustrated by breakfast drinks). However, compliance to governmental food laws is now essential for market launch (as illustrated by fat substitutes in the EU). The essential factor for a high degree of replacement by food substitute is consumer acceptance. Successful food substitutes were in line with consumer trends and needs (like health for sugar substitutes, convenience for breakfast drinks) and had a relatively high product quality (not the case with TVP). Food substitutes obviously need to be considered as a specific type of food innovations. These products need to replace existing products or ingredients, and therefore are directly compared to the original product in terms of quality offered to consumers. A high degree of similarity to the original product is important, especially with substitution on a macronutrient or product level. Time is therefore also an important factor, which facilitates further technology advancements, product optimization, and the process of changing eating patterns by consumers.

2.1 INTRODUCTION

Recent trends in society that are currently under attention, such as increasing obesity rates and environmental pollution, are associated with the type of foods and how foods are produced (Duchin, 2005; McMichael, Powles, Butler, & Uauy, 2007; WHO, 2003). This has pushed the search for attractive alternative food products that can be offered to consumers. Examples include investigations into lower energy density products with a higher satiety value for maintaining a healthy weight or meat substitutes that have less environmental impact than large-scale meat production (Aiking, de Boer, & Vereijken, 2006; Fry & Finley, 2005; Serrano & González, 2008). There is thus a need for *food substitutes* that can replace current products that are less optimal with respect to these issues (e.g. current high calorie foods, products with a high environmental load). This is not so easy however. Firstly, changing the composition of foods can have an impact on organoleptic properties, for example fat contributes profoundly to the flavour, texture and mouth feel of food products. It is thus a challenge to develop lower-fat products that have a similar sensory product quality to the original products and which are more attractive to consumers (e.g. ADA, 2005; Colmenero, 2000). Secondly, new food substitutes can face challenges with respect to food safety, due to the use of not yet approved compounds, higher product prices, due to increased processing, or require major changes in food choice behaviour of consumers (e.g. Borzelleca, 1996; Frazao & Allshouse, 1995).

On the other hand, there are also food substitutes (e.g. margarine, diet coke) that obviously succeeded in substantially replacing the original product (butter and regular coke, respectively). Why did these substitutes succeed? Which factors contributed to this? What can we learn from this for the development and introduction of new food substitutes?

Objective and approach

This chapter aims at getting insight in key factors in the development of food substitutes and subsequent substitution of original food products in the diet. We will do this by retrospection and consider previous food substitutes in the context of advances in technology, governmental policies and consumer trends. The scope of this analysis is the Dutch market, which can be considered representative for Western-Europe, and the time period from 1870 to 2000, in which major changes took place in food product development (Otterloo, 2000). The remainder of the chapter is organized as follows: first we will give a definition of food substitutes and how these can be classified. After that we will review some typical cases of food substitutes in the context of historical developments. Finally, we will conclude with a discussion about

preconditions and crucial factors in substitution and the specific challenges imposed upon food substitutes.

2.2 DEFINITION AND TYPES OF FOOD SUBSTITUTES

What exactly are substitutes? Intuitively one thinks about certain products that are used instead of other products. However, there is not one strict definition and there are obviously different interpretations as illustrated by these following four examples from different disciplines.

1. Marketers consider substitution for example when consumers experience that their preferred item is out of stock and consequently need to switch to a substitute from the same store. Substitute products are then the same type of products but from a different brand, (e.g. Anupindi, Dada, & Gupta, 1998; Kraiselburd, Narayanan & Raman, 2004), e.g. a Coca Cola replaced by a Pepsi soft drink.
2. From a price elastic point of view, substitutes have been described as products that lead to an increase in sales of other products when prices are raised (e.g. Bucklin, Russell, & Srinivasan, 1998), e.g. a Coca Cola replaced by a water bottle.
3. Substitution-in-use research regards substitutes as products that are perceived by consumers to be functionally similar in a specific usage situation. These products can even be physically dissimilar and from multiple categories (Ratneshwar & Shocker, 1991), e.g. a Coca Cola replaced by a coffee.
4. Food regulators apply a much stricter definition of substitutes with the purpose of maintaining the food safety of new products by making comparisons with existing products. According to the Food Law (Warenwet, 1999), a substitute is an *enriched* food/drink that aims to replace an existing product and is as much as similar to this existing product with respect to appearance, consistence, taste, colour, flavour and usage purpose, and at which one or more micronutrients are added at a maximum of the naturally occurring levels in the food/drink that is substituted. E.g. a Coca Cola compared to a Coca Cola with added vitamin C.

From a food technology point of view, we define food substitutes as follows in this chapter[1]:

[1] It needs to be said that our working definition is not conclusive and certainly leaves room for discussion. However, it is meant as a further specification and clarification for the wide range and abstract level of other definitions of substitutes.

'A food substitute is a food or food component, modified with respect to a reference food or food component from the same category, with the aim to replace it in the same usage situation'

So we focus on food products or components that are deliberately modified or developed to substitute other food products or components with a similar purpose, but exclude multi-category substitutes. The degree of similarity with the original product as perceived by consumers might vary, and substitutes are in our view not necessarily enriched with micronutrients. The reference food product is the product which is being substituted and that was already on the market before the substitute entered (Shocker, Bayus, & Kim, 2004). Note that with modification, we specifically refer to substitution, which thus holds the introduction of *other* components that were previously not present in the food product: one component or several components are taken out and other component(s) are put in. The following products are therefore *not* considered as food substitutes in our investigation in this topic:

- Varieties of an original product with supplements added (e.g. a Coca Cola with vitamin C).
- Varieties with an altered composition without new ingredients added (e.g. a Coca Cola with less sugar, but no artificial sweeteners)
- Certain flavour varieties of products (e.g. a Coca Cola with lemon flavour)
- Brand varieties (e.g. a Coca Cola replaced by a Pepsi coke)
- Products across categories (e.g. a Coca Cola replaced by an ice cream)
- Products with an altered processing or production technique but without intended modification of product properties (e.g. an organic Coca Cola)

A good example of food substitute is a diet Coca cola substituting regular Coca Cola: it is also a soft drink (same category), not a brand variety, the food product has been deliberately modified (less calories) by using components that have a similar purpose (the sweetener sugar is taken out and replaced by aspartame).

We also consider different types of food substitutes depending on which part of the original food product(s) is actually substituted. Foods can be structured following a hierarchical pattern in units, from nutrients to complete dietary patterns (Jacobs & Tapsell, 2007; Meiselman, 2000). These so-called food units (nutrient, product, and meal) can also be applied for the arrangement of different types of food substitutes[2]:

[2] We acknowledge that this arrangement in food substitutes is not necessarily how consumers would classify products. However, our goal is not to use this as a classification system that needs to be directed to consumers. It is meant as a functional arrangement to structure the relevant data with respect to food substitutes.

— Substitution on a nutrient level: only a macronutrient of a product is intentionally replaced. The resulting food substitute has thus primarily another macronutrient component, while the remaining product matrix is largely the same.
  Examples include sugar substitutes as applied in drinks, sweets, and diabetic products. Fat substitutes as applied in dairy products, savoury snacks, meats, etc.
— Substitution on a product level: not only macronutrients but the entire product matrix is replaced. Examples include soymilk, meat substitutes, margarine, and surrogate coffee. This type of substitution does not necessarily affect the combination of accompanying food products in a meal or eating moment.
— Substitution on a meal level: the entire combination of different products as used in a meal moment is substituted by a food substitute. Examples include breakfast drinks, sports meal bars, meal replacement shakes, and so on.

We take these different levels of substitution into account in our analysis, since these might impact the overall product quality of food substitutes. In the next sections some food substitutes will be illustrated in detail, after setting the scene with relevant developments from 1870 to 2000.

2.3 FOOD SUBSTITUTES IN CONTEXT OF HISTORICAL DEVELOPMENTS

The occurrence of food substitutes, as specific types of food innovations, should be considered in the context of historical developments in food production and consumption. Food industry innovations were related to changing social and economic trends such as food availability, demographics, economy, and consumer lifestyle patterns (Foster & Lunn, 2007; Golan & Unnevehr, 2008). The development and acceptance of food products thus involves different actors and is highly interconnected and dynamic with linkages between government, industry, and the consumer (Desmarchelier & Szabo, 2008; Otterloo, 2000).

Changes in food production and consumption[R]

Considerable changes in society took place in the Netherlands from 1870 to 2000, alike other Western-European countries, which affected our eating patterns and the ways of food production. The start of that time period is characterized by a changing economical/social context. Due to the rapidly growing urbanization, people were not able to grow their own foods in their own backyard anymore. This led to a high demand for foods produced elsewhere and was the beginning of an industrialized way of food production by food industry.

Food technology advanced slowly but steadily due to the increased knowledge of foods and processing. Scientific progress (e.g. pasteurization) resulted in application

in new types of products: preserved, processed and packaged foods. Over time, the development of food substitutes became possible due to insight in chemical structures and thereby food industry could develop 'synthetic' copies.

Governmental policy measures influenced food production and consumption in different ways. Investments in knowledge and science promoted the advances made in food technology. The central production of foods led to regulations to guard food hygiene and protect consumers (Dutch Food Law established in 1917, overarched by the European Food Law in 2002). Other policy measures of influence were trade and patent policies and consumer campaigns.

Consumer trends and needs have changed over time and were closely related to the economical/social trends. The time-period from 1870-2000 is first of all marked by a reversal from scarcity to abundance, from 1960s onwards, by increasing welfare. However, there were serious times of food scarcity in the period during and between WWI en WWII, which led to development of certain substitutes (e.g. surrogate coffee and tea). The growing consumer trends towards health and convenience characterize the past 50 years. The relation between nutrition and health has become apparent due to scientific insights and was adopted by industry, government and consumers. The need for convenience needs to be seen in the context of changing work and life patterns (e.g. more women at work). Eating patterns changed with this in the direction of out-of-home dining, while in the home easier products with less preparation were desired (e.g. ready meals by new cooking methods such as the microwave oven).

In conclusion, the development and acceptance of food substitutes was largely influenced by an interplay between food technology advances, governmental policies, and consumer needs and societal trends. These factors will be specified for a number of food substitute cases in the next section.

[R]*References of this section:*
Bakker, 1992; Bijman, Pronk, & De Graaff, 2003; Den Hartog, 2001; Desmarchelier & Szabo, 2008; Foster & Lunn, 2007; Golan & Unnevehr, 2008; Jobse-van Putten, 1995; Otterloo, 1990; Otterloo, 2000; Vijver, 2005.

Illustration by cases of food substitutes

We made a selection of five food substitutes to illustrate how different factors have influenced the development and acceptance of these products. These food substitutes appeared on the Dutch market between 1870 and 2000 and are listed in Table 1: sugar substitutes, fat substitutes, margarine, TVP (texturized vegetable protein), and breakfast drinks. These particular food substitutes were selected because they reflect the different types of food substitutes (macronutrient level, product level, and meal level), were developed or marketed in different times, and differ in success in substituting the reference product. Since success is a subjective term, we used the

actual levels of penetration (market shares) compared to those of the reference product and the classification according to Shocker et al. (2004):

- Substitute replaces the reference product
- Substitute and reference product co-exist together
- Substitute fails to substitute the reference product

We added to these three categories the following:

- No market entry of the substitute

We illustrate the food substitutes in order of their success in The Netherlands – thus listed from margarine to fat substitutes, and take margarine as a successful food substitute for comparison. Table 2.1 gives full details of product descriptions with product benefits, resemblance and challenges compared to the reference product, the time period and duration of development, and the relevant factors as described in previous section (technological advances, policy measures, and consumer trends and needs).

Margarine has substituted the reference product butter to a large degree in the Netherlands. The food substitute had seemingly a large number of factors working in the positive direction. It started in France where the *government* invested in finding a new cheap substitute for butter. A *new technique* was found to make a substance called oleomargarine initially from body fat of cattle, later vegetable sources were used. In the Netherlands, there was *no patent regulation* at that time, so the technique was adapted and further optimized and the margarine production was able to flourish. However, the butter law was implemented to protect consumers from confusion with butter (Table 2.1). In the beginning, margarine *fitted the needs* of the poor and lower middle class in times of scarcity to have a spread that was better than the very low quality butter mixtures. Margarine was less than half the price of butter at that time. However, it should be noted that the product quality was low at first, and consumers switched back to butter as soon as butter prices decreased. The time period from initial development to current degree of substitution (around 90%) is striking (Table 2.1) *Over time, so now for more than 100 years, there were constant product quality improvements* by using new techniques and ingredients and thereby optimising processing and taste. The *resemblance to butter* was further increased by added vitamins, and the fat composition of margarine was adjusted according to current nutritional guidelines concerning saturated fatty acids (Foster, Williamson, & Lunn, 2009; Massiello, 1978; Moskowitz, 2001; MVO, 2009; Otterloo; 2000; Verbeek, 1992; Vijver, 2005).

Sugar substitutes *fit the consumer health trend* and offer the possibility to make food products with less sugar and calories or dental damage compared to reference products. Sugar substitutes are widely applied in other products, and thus less often eaten independently. *Technology was needed to make synthetic copies* of sugar with a similar taste and less aftertaste, which took 30 years before market launch (Table 2.1). Although the taste

is maybe not exact like sugar, the widespread use indicates the acceptance of consumers: the consumption of diet soft drinks in the Netherlands is still growing and the percentage of total soft drinks consumed increased from 26% (2004) to 31% (2008); so one third is now substituted (Table 2.1). Governmental policy primarily influenced the regulatory approval; not all sorts of sugar substitutes are currently allowed (ADA, 2004; Alonso & Setser, 1994; Butchko et al., 2002; FWS, 2008; Hulshof et al., 2004; Mortensen, 2006).

Breakfast drinks *fit the need for convenience* foods. A breakfast drink offers *unique benefits* compared to a traditional breakfast as it replaces time for both preparation and consumption. On a convenience scale this is full service; nothing more than opening a can or box is needed. Different products are replaced by this food substitute product (e.g. bread, milk, fruit juice) and *a similarity to the taste of reference products is therefore not needed*. This food substitute is seemingly largely driven by tapping into consumer needs; there were *no large technological breakthroughs, and no governmental influences* besides the food regulation criterion. As this product is *relatively young*, more growth on the market is expected. In a short time period the current degree of substitution is already around 30% (Table 2.1) (Bijman et al., 2003; GFK, 2005; Harrison, 1979; Hulshof et al., 2004; NEVO, 2006).

TVP, as a substitute for meat, is an example of a food substitute failure. The product is often characterized by its *low product quality* compared to meat, both with respect to taste and preparation (it needed 1,5 hours of soaking in water!). It is said that *limited time* was taken; there was an up-speeded production and *no market research* performed in the Netherlands. It was meant as an attractive alternative protein source to meat but *consumers mistrusted* this new 'synthetic' product. So despite *initial call of (international) governmental bodies* to search for alternative protein sources, the solution was obviously not brought by this food substitute. The short time between development and market launch is striking (Table 2.1) (Aiking, et al., 2006; Liu, Peng, Tu, Li, Cai, & Yu, 2005; Otterloo; 2000; Vijver, 2005).

Fat substitutes are macronutrient substitutes comparable to sugar substitutes with respect to the current *consumer needs for less calories or low fat foods*. However, the *product is not allowed* on the market in the Netherlands due to EU *novel food regulations.* The development faced more *technological challenges* and took *more time* than sugar substitutes in order to produce a product with similar functional and sensory properties as the reference fat, and without undesirable side-effects (Table 2.1). The total effort of the development work was large, as indicated by the costs of investments: for Olestra this has been estimated at $200M (ADA, 2005; IFST, 2004; Michicich, Vickers, Martini, & Labat, 1999; Munro, 1990; Neumark-Sztainer et al., 2000; Roller, & Jones, 1996).

Table 2.1: Overview of different examples of food substitutes

	Food substitutes				
	Sugar substitutes	Fat substitutes	Margarine	Texturized vegetable protein (TVP)	Breakfast drink
Type of food substitute	Macronutrient substitution	Macronutrient substitution	Product substitution	Product substitution	Meal substitution
Reference products substituted*	Sugar (sucrose)	Fat	Butter	Meat and other animal flesh	Breakfast meal
Product description	*Composition* Artificially-synthesized Compounds or by catalytic hydrogenation 2 main types: polyols (P), e.g. sorbitol, and high intensity sweeteners (HI) e.g. aspartame	*Composition* 3 classes of fat substitutes: - Carbohydrate-based Such as from cellulose, dextrins, maltodextrins, polydextrose, gums, fibre, and modified starch - Protein-based Microparticulated protein (e.g. Simplesse), or milk and egg protein - Fat-based chemical alterations of fatty acids, sucrose polyester (e.g. Olestra)	*Composition* Spreadable product now from water and plant-oils (e.g. soy oil, sunflower oil, linseed oil, rapeseed oil). Initially animal fat used for oleomargarine, and cow's milk added Now supplemented with vitamins A, D and E	*Composition* Main ingredient is defatted soy flour, added flavouring needed	*Composition* Dairy or fruit based drinks (fruit juice and pulp) Supplemented with vitamins B, C or E and fibres
	Applications E.g. soft drinks, juices, dairy products, sauces, syrups, candies, frozen desserts, baked goods and chewing gum	*Applications* E.g. in the USA in savoury snacks, confectionary, cereal grain products, baked foods, dairy products	*Applications* Packaged table spread and ingredient for other foods, like bakery products	*Applications* Small pieces to be used as a meal ingredient	*Applications* Packaged or bottled

	Food substitutes				
	Sugar substitutes	Fat substitutes	Margarine	Texturized vegetable protein (TVP)	Breakfast drink
	Product benefits - Less calories (average 2 kcal/g compared to 4 kcal/g of sugar)- Not metabolized by bacteria in the mouth (polyols) - Low glycemic response	*Product benefits* - Less calories (from 0 to 9 kcal/g compared to 9 kcal/g of fat) or not metabolized and absorbed by the body	*Product benefits* - Initially affordable alternative for butter - Now also referred to as a 'healthier' fat composition than butter	*Product benefits* - Plant protein source, no meat or meat by-products - Long shelf life - Light weight - Relatively low price	*Product benefits* - Convenience, less time for preparation and consumption - Suitable for on the go
	Resemblance to reference product Relatively high degree of sensory quality, mimics original taste	*Resemblance to reference product* Initially challenges, with new fat substitutes better resemblance to sensory properties of fats	*Resemblance to reference product* In the beginning poor, now a high degree of sensory similarity	*Resemblance to reference product* Very poor	*Resemblance to reference product* None, replaces several products with different properties
	Product challenges - Intestinal side effects - Not all functional properties of sugar: browning, crystallization, etc. (HI) - Less sweet (P) - Some with aftertaste	*Product challenges* - Laxative effects - Loss of fat-soluble vitamins in diet - Need to compensate for functional properties of fat (taste, texture, mouth feel, lubrication, volume/bulk, heat transfer)	*Product challenges* Initially: - Sensory quality - Spreadability	*Product challenges* - Inferior sensory quality - Intensive preparation needed before consumption (1,5 h soaking in water needed to rehydrate the substance)	*Product challenges* Nutritional value comparable to breakfast
Time and period	- 1879 first discovery saccharin - 1950 actual processing - 1960 aspartame discovered - 1987 widespread application in food industry	Olestra as an example of the time needed: - 1968 discovery of Olestra - 1998 product on the market in the USA	- 1869 oleomargarine invented in France - 1872 first margarine factories in NL (export) - 1884 product on Dutch market	- 1960 development in US - 1968 on the Dutch market - 1969 off the Dutch market	- 1997 first product on the Dutch market

	Food substitutes				
	Sugar substitutes	Fat substitutes	Margarine	Texturized vegetable protein (TVP)	Breakfast drink
Governmental policy measures**	- The use of sweeteners in the EU is regulated by a framework directive (food additives) and a specific directive (sweeteners) - Food safety assessments responsibility by EFSA - Extensive safety evaluation including animal and human studies and in vitro and in vivo toxicological testing - Not permitted: alitame and neotame	Market entry blocked by law. No approval in EU due to food safety issues	- Initial high investments in development and knowledge to deliver a substitute for butter for working class people - No patent law from 1869-1910 - Butterlaw in 1889: labelling indicating margarine needed - Fortification with vitamins	Initial stimulation (subsidies) to look for plant-protein alternative products within the scope of decrease of world malnutrition	None specific, compliance to general food regulations needed
Technology advances	- Upscale production of synthetic products was needed - Optimization of physical properties (stabilising, bulk, heat) was needed	Technology needed highly dependent on type of fat substitute. Includes; - Optimization of staged processes (e.g. gelation, enzyme treatment, heating) - 'Synthethic' substitutes - Up scaling challenges	After the big step of inventing oleomargarine, consecutive smaller steps of mechanical and chemical improvements along with changing ingredients and up scaling.	Extrusion. Needed further development and optimization of the process and extruders. Initially only with low-moisture food and single-screw extruders. Polishing steps needed to improve the quality.	Mainly application of existing technologies: preservation, stabilisation, and taste optimization needed.
Consumer trends and needs	Increased attention for 'healthier' foods - Weight control, less calories - Dental care - Diabetes	Need for products with less calories or low in fat	- Initial good substitute for the lower class, lower price - Times of scarcity (until 1960's) - Later probably also health benefits	Vegetarians and vegans, need for meat-free products	Convenience and out-of-home eating

	Food substitutes				
	Sugar substitutes	Fat substitutes	Margarine	Texturized vegetable protein (TVP)	Breakfast drink
Degree of substitution	Substitute and original co-exist together	In NL and EU no market entry yet, as opposed to the USA	Original products largely substituted	Substitute failed	Substitute and original co-exist together
	- Estimated 33% of Dutch population uses sugar substitutes regularly - Popular products with sweeteners are drinks (88% of products with sweeteners used) - 31% of soft drinks consumed are now diet drinks	- E.g. most fat substitutes, like Olestra, not allowed (note that Salatrim is allowed in the EU for small amounts in bakery products)	- Estimated 90% market share of spreads	- Went off the market in 1969 - Now marginally in specialised organic stores available via import	- Estimated 30% of the Dutch population uses a breakfast drink regularly

*The reference product is the product, or ingredient, which was already on the market before the substitute entered, and which is being substituted by the food substitute.
**Policy measures: only food regulations, patent regulations and knowledge investments are described if relevant for the development, launch, and acceptance of the food substitute.
References: ADA, 2004; ADA, 2005; Aiking, et al., 2006; Alonso & Setser, 1994; Bijman et al., 2003; Butchko et al., 2002; FWS, 2008; GFK, 2005; Harrison, 1979; Hulshof et al., 2004; IFST, 2004; Kuik, 2004; Liu, Peng, Tu, Li, Cai, & Yu, 2005; Massiello, 1978; Michicich, Vickers, Martini, & Labat, 1999; Mortensen, 2006; Moskowitz, 2001; Munro, 1990; MVO, 2009; Neumark-Sztainer et al., 2000; NEVO, 2006; Otterloo; 2000; Roller, & Jones, 1996; Verbeek, 1992; Vijver, 2005.

2.4 FACTORS IN DEVELOPMENT AND ACCEPTANCE OF FOOD SUBSTITUTES

The previous sections illustrated how different factors may drive or limit the development and acceptance of food substitutes. It is obviously necessary to consider these factors altogether and over a larger period of time, since these factors are linked to each other and embedded in the economical/social context of a certain era. The success of the food substitute margarine in replacing butter can probably not be explained by a few factors in isolation, such as only by the lower pricing or initial governmental support, but was in fact a multi-factorial process (Den Hartog, 2001; Otterloo, 2000). The cases of food substitutes and the factors that acted upon the development and degree of acceptance are diverse, e.g. there were technological advances needed for sugar substitutes but less for breakfast drinks, while these are both relatively successful food substitutes. Initial governmental support and investments were put both in the development of margarine and TVP, while the latter

food substitute failed. We therefore cannot conclude with summarizing a single factor that determines the success for food substitutes. However, the food substitute cases are all similar in one respect: the degree of replacement largely depends on a fit with consumer needs and the product quality of the food substitute, while governmental policy measures and technology advances could have positively influenced the way to get there.

In the sections below we offer a standpoint on food substitution by discussing the role of each of the factors in more detail. The specific demands on food substitutes' product quality in order to achieve consumer acceptance will be discussed as well.

The influence of governmental policy measures on substitution

In one way governmental policy measures are of *direct* influence whether food substitutes appear on the market at all, and that is by laws with respect to food safety and consumer protection (e.g. Kuik, 2004). Compliance to these regulations is an *essential precondition* for food substitutes to be marketed. These regulations have changed over time and where not in place when food substitutes margarine and TVP came on the market. At the time margarine was developed there was not even a strict patent regulation in the Netherlands, which gave more freedom to copy and optimize the development process (Verbeek, 1992). Nowadays, novel foods need to be approved by regulatory instances for market entry due to the Novel Food Regulation (since 1997) (Hermann, 2009; Kuik, 2004). The same steps apply for new food substitutes using novel foods or novel ingredients[3], like fat substitutes, which are not yet approved by the EU (Roller, & Jones, 1996).

Governmental policies can also have a positive influence on the development and ultimate consumption of food substitutes by investing in knowledge gain and transfer or promotion of certain eating patterns (e.g. less calories, or more environmentally friendly food choices) (Allen, 2009; Foster & Lunn, 2007; Morgan, Blake, & Poyago-Theotoky, 2003). These are probably *not essential* for acceptance of food substitutes as illustrated by the example of breakfast drinks.

It is often a subject of debate whether government can and should play a bigger role by using price measures, like taxes and subsidies to promote healthier or more environmentally friendly eating patterns (e.g. Aiking et al., 2006; Alderman &

[3] Novel foods or ingredients are foods or ingredients (Hermann, 2009; Kuik, 2004):

- Which are produced from genetically modified organisms or which contain such organisms;
- Which present a primary molecular structure;
- Which consist of micro-organisms, fungi or algae;
- Consist of, or are isolated from plants, or isolated from animals, except for foods and food ingredients obtained by traditional propagating or breeding practices with a history of safe use;
- Whose nutritional value, metabolism or level of undesirable substances has been significantly changed by the production process.

Daynard, 2006; Blaylock, Smallwood, Kassel, Variyam, & Aldrich, 1999; Mercer et al., 2003). Generally, these are expected to have limited effects. For new sustainable food substitutes, such as meat substitutes, economic analyses have been performed to investigate this. Herok (2003) suggested that a 20% consumer subsidy on new meat substitutes in the Netherlands would have a modest effect on consumption of these foods, namely only +1.6%. Thus for the promotion of these types of foods, not too much should be expected of traditional government instruments such as taxes and subsidies (Kuik, 2004).

The influence of technology advances on substitution

The knowledge of foods and food processing techniques have increased tremendously when we consider the entire time period from 1870 to 2000 (Otterloo, 1990; Otterloo, 2000). In 1870 it would obviously not have been possible to produce for instance sugar substitutes as we know now. So some sort of technological progress is needed to create new opportunities for food products that could not be produced previously (Van Trijp & Steenkamp, 1998; Siegrist, 2008), which is related to the socio-economic progress over time (Earle, 1997). This influences the development of food substitutes as a specific type of new food products. However, this does not mean that radical technological breakthroughs are necessary. Moskowitz & Hartmann (2008) argue that 'mammoth innovations' in the food world are scarce and that it is difficult, but certainly not essential, to have true innovations. They refer to current innovations, like 'rearranging components in the same old boxes' as done with lower calorie ingredients substituting for higher calorie ingredients in foods. Thus innovation does not need to result from new high-tech advances in order to lead to competitive advantage (Grunert et al., 2008). For food substitutes as any type of new food products, the determinant of success is the degree of fit between the new product and consumer needs (Van Trijp & Steenkamp, 1998; Van Trijp & Van Kleef, 2008, Stewart-Knox & Mitchell, 2003).

The influence of consumer needs and product quality on substitution

Food substitutes that were successful on the market fitted consumer needs, whether this was a product with less calories (e.g. a coke with sugar substitutes), a more convenient product (breakfast drink) or a more affordable tasty alternative (e.g. margarine). The fulfilment of certain consumer needs should be the goal of any new developed food product (e.g. Urban & Hauser, 1993; Van Trijp & Steenkamp, 1998), and it is not something new. However, what makes the position of food substitutes more specific, and maybe more difficult, is the direct competition with a reference product that is already on the market (Shocker et al., 2004).

The perceived product quality[4] of a food substitute cannot be considered in isolation and in absolute sense, but is judged relatively to the reference product. So if less calories is an important attribute to someone, a diet Coca Cola will be of greater value to that person than an original Coca cola. Another person who finds the true sugar taste more important than less calories would prefer the original Coca Cola. The importance to outperform the reference product on certain qualities by a food substitute (e.g. animal welfare), and to uphold essential quality criteria (e.g. good taste and easy preparation) for at least some consumers is illustrated by the failed meat substitute TVP.

A specific flavour of a highly-liked original product (e.g. the taste of sugar, butter, meat) can be an important quality attribute to consumers. Hence, there have been large investments and efforts to try to mimic these as much as possible, which has shown to increase consumer acceptance over time (e.g. improved sugar substitutes, improved taste of margarine). Technological progress has influenced this positively. A certain degree of similarity to the reference product is thus very important from the sensory quality perspective. In addition, similarity to a reference product seems to go beyond ensuring that highly-liked attributes are represented in new food substitutes. Similarity judgments are in fact an essential element in the process of decision making between two alternative products (Medin, Goldstone, & Markman, 1995; Tversky, 1977). This comparison to the 'familiar' reference gets even stronger when a product is relatively new (e.g. Michaut, 2004; Van Trijp & Van Kleef, 2008). The importance of similarity for food substitutes on a product or macronutrient level was supported by the food substitute cases in previous sections. Obviously, similarity requirements are different for substitution on the meal level (e.g. breakfast drink, sports bars or diet shakes). We think this is due to the fact that this type of food substitute does not need to be combined with other products (e.g. margarine on bread, fat substitute in milk) which avoids a direct comparison to the reference product (e.g. butter on bread, full fat milk). Products that come from different categories but that are used for similar goals or in similar usage situations obviously do not need to be physically similar (Barsalou, 1983; Ratneshwar & Shocker, 1991). For new food substitutes this is an interesting route to explore and test further, such as applying new meat substitutes in new types of ready-to-eat meals.

Time is also a factor of importance in food substitution by consumers. Eating patterns have changed, and are still changing, but these changes are gradual and do not occur overnight (Den Hartog, 2001; Otterloo, 2000). As illustrated by the margarine case, it seems that a significant period of time (probably over 50 years) is needed before a new

[4] Note that the perceived quality is not just a sum of product attributes, but yields an overall evaluation on the relevance of these attributes to consumers (e.g. Grunert, 1997; Grunert et al., 2008). Therefore, this section discusses both consumer needs and product quality because they are related.

food product is adopted and creates its own identity and status (e.g. see the adoption-diffusion model, Rogers, 1995). It would be interesting to analyse this type of data in more detail for a large number of new food products and food substitutes in particular.

2.5 IN CONCLUSION

Food substitutes are an interesting route to achieve a healthier or more environmentally friendly eating pattern by consumers. However, the success story of margarine replacing butter must not be oversimplified and projected on to future food substitutes. A number of dynamic, interacting, factors play a role in substitution and development and acceptance of food substitutes. Positive preconditions, but not essential, are certain technological advances and an increased level of knowledge which can be supported by governmental policies. These factors play primarily a role in the development phase. It is however essential for new food substitutes to comply with governmental regulations to be launched on the market. In the end, consumer acceptance is crucial. After launch, food substitutes are only able to substitute the original product to a significant degree when they fit consumer needs and are of high quality, especially sensory quality.

Food substitutes need in fact to be considered as a specific type of new food products. Food substitutes (macronutrients and products) are directly competing with reference products and as a result they need to be both similar and offer added value.

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Chapter 3

Chapter 3A

Food-related lifestyle and health attitudes of Dutch vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers

Chapter 3B

Replacement of meat by meat substitutes: A survey on person- and product-related factors in consumer acceptance

Chapter 3a

Food-related lifestyle and health attitudes of Dutch vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers

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ABSTRACT

The aim was to investigate socio-demographic characteristics, and attitudes to food and health of vegetarians, *non*-vegetarian consumers of meat substitutes, and meat consumers in the Netherlands. The sample used for this study (participants ≥ 18 years) was taken from the Dutch National Food Consumption Survey 1997/1998. Vegetarians (n = 63) and consumers of meat substitutes (n = 39) had similar socio-demographic profiles: higher education levels, higher social economic status, smaller households, and more urbanised residential areas, compared to meat consumers (n = 4313). Attitudes to food were assessed by the food-related lifestyle instrument. We found that vegetarians (n = 32) had more positive attitudes towards *importance of product information, speciality shops, health, novelty, ecological products, social event, and social relationships* than meat consumers (n = 1638). The health consciousness scale, which was used to assess attitudes to health, supported earlier findings that vegetarians are more occupied by health. Food-related lifestyle and health attitudes of meat substitute consumers (n = 17) were predominantly in-between those from vegetarians and meat consumers. The outcome of this study suggests that in strategies to promote meat substitutes for non-vegetarian consumers, the focus should not only be on health and ecological aspects of foods.

3A.1 INTRODUCTION

Our food choices do not only affect our own health, but the health of our ecosystems as well. Present food production systems, and meat production in Western society in particular, place a heavy burden on the environment. Besides pollution of air, soil, and water, negative environmental effects arise from the energetically inefficient conversion of feed into meat by animals: 1 kg of meat requires 3-10 kg of grain (Tilman, Cassman, Matson, Naylor, & Polasky, 2002). From a further increase in consumption of livestock products expected for the next 50 years on a global level, the inevitability of a more sustainable food production follows as a matter of course. Purely from an environmental point of view, substituting consumption of meat by alternative protein rich products made from plant proteins, so-called Novel Protein Foods, would be an attractive option (Jongen & Meerdink, 2001; Smil, 2002). But would that also be attractive to consumers?

Traditional vegetarian products such as tofu and tempeh have been eaten for centuries in Asian countries. Just recently in the nineties, new meat substitute products such as Tivall or Quorn, became widely available in Europe (Davies & Lightowler, 1998; McIlveen, Abraham, & Armstrong, 1999). Despite the increase in popularity of meat substitutes since several food-safety crises in the meat industry, the market share (in volumes) of meat substitute products as a meal component was still 1% compared to 76% of meat and poultry in the Netherlands in 2002 (PVE, 2003). Meat substitute products are therefore not yet absolute alternatives for meat to the majority of consumers, except for vegetarians.

The term 'vegetarian' is not very straightforward, but it generally describes a range of diets that avoids animal flesh (meat, fish and poultry), with varying degrees of restriction (British Nutrition Foundation, 1995; Silverstone, 1993). Vegetarian diets are not only associated with a decreased frequency of meat consumption, moreover with a particular belief or lifestyle. Moral and ethical beliefs, consisting of rejections of killing animals and concerns for animal welfare are reported as the main reason to avoid meat in the Western world (Beardsworth & Keil, 1992; Kalof, Dietz, Stern, & Guagnano, 1999; Kenyon & Barker, 1998; Worsley & Skrzypiec, 1998). Vegetarians obviously express a certain philosophy in their choice of foods (Allen, Wilson, Ng, & Dunne, 2000; Lindeman & Sirelius, 2001; Twigg, 1983). Besides moral and ethical beliefs, health reasons seem to play an increasing important role to hold a vegetarian lifestyle nowadays (Barr & Chapman, 2002; Jabs, Devine, & Sobal, 1998). The appearance of so-called part-time vegetarians has also been explained in the perspective of an increasing number of health consciousness consumers (Janda & Trocchia, 2001).

For promotion of environmentally acceptable Novel Protein Foods it is essential to know if current consumers of meat substitutes, other than vegetarians, have a

higher interest in environmental and health issues as well. The aim of this study was therefore to compare socio-demographic characteristics and attitudes to food and health between vegetarians, non-vegetarian consumers of meat substitutes, and meat consumers in the Netherlands.

3A.2 METHODS

Socio-demographic characteristics

We used data from a nation-wide sample of the Netherlands, the Dutch National Food Consumption Survey 1997/1998 (DNFCS), to identify vegetarians, non-vegetarian consumers of meat substitutes and meat consumers, including their socio-demographic characteristics. The initial purpose of this survey was to describe consumption, and its development over time, of different food groups in the Netherlands. Food consumption data were collected from April 1997 until March 1998, by means of a 2-day food diary of a representative random sample survey of households in the Dutch population with a caretaker aged <75 years. In addition, a sample of households with a caretaker >75 years was obtained, which resulted in a total sample of 6,250 subjects aged 1-97 from 2,564 households (Figure 3a.1). Recording days were equally distributed throughout the week and across seasons, but not during holidays (Hulshof, Kistemaker, & Bouman, 1998). Besides information on food consumption of the respondents, personal data were assessed and inquiries were made on specific dietary lifestyles.

For our purposes, the additional elderly sample of DNFCS and persons younger than 18 years were excluded from analysis to minimise influences of parents or nursing homes in the choice for a certain diet. Respondents with other specific dietary lifestyles, such as macrobiotic or anthroposophic, were excluded from our study. The remaining respondents were assigned to one of the following groups (Figure 3a.1):

1. Vegetarians (n = 63)
   Vegetarians were respondents who indicated to have a vegetarian dietary lifestyle (i.e. eating meat less than once a week). Vegans (n = 6), often referred to as strict vegetarians, were also included in the vegetarian group and were respondents who indicated to have a strict vegetarian lifestyle.
2. Consumers of meat substitutes (n = 39)
   Consumers of meat substitutes were respondents who recorded the consumption of at least one meat substitute product and who did not indicate to be vegetarian.
3. Meat consumers (n = 4313)
   Meat consumers were respondents who did not indicate a specific dietary lifestyle and did not consume a meat substitute product during the recording days.

Based on literature (Freeland-Graves, Greninger, & Young, 1986; Jabs et al., 1998; Perry, McGuire, Neumark-Sztainer, & Story, 2001) describing socio-demographic characteristics associated with vegetarianism, we selected the following variables for our study: gender, age, household size (number of persons in the household), education level (from primary school to university training, categorized into 7 classes), gross household income (from € 0 to >€ 3,630, categorized into 15 classes), degree of urbanization of residential area (from <500 addresses/km^2 to >2,500 addresses/km^2, categorized into 5 classes) and social economic status (SES, based on educational, occupation and occupational position, and categorized into 5 classes). The number of persons with a vegetarian housemate was also taken into account for both vegetarians and consumers of meat substitutes, in order to verify potential social influence on specific dietary lifestyle or consumption of meat substitutes. Meat substitute products available in 1997 and 1998 were defined according to Dutch Nutrient Database codes 1996 (NEVO, 1996) as tofu, tempeh, Tivall, and Quorn, for example vegetarian burgers, schnitzels and stir-fry products.

Food-related lifestyle instrument

The food-related lifestyle instrument (Bredahl & Grunert, 1998; Brunsø & Grunert, 1998; Grunert, Brunsø, & Bisp, 1997) was used as a tool to measure attitudes to food, i.e. how people link food to the attainment of life values, and to compare these between vegetarians, consumers of meat substitutes, and meat consumers. This 69-item questionnaire (7-point scales, from 'totally disagree' to 'totally agree') measures 23 lifestyle dimensions, which cover the assessment, preparation and actual consumption of food products: *ways of shopping, quality aspects, cooking methods, consumption situations and purchasing motives.* The construct validity of the food-related lifestyle dimensions has been extensively tested, indicating that the factor structures are stable across cultures and over time (Scholderer, Brunsø, Bredahl, & Grunert, 2005). The questionnaire was translated into Dutch and rated by a subset of DNFCS respondents that were holding main responsibility for household shopping and cooking (Figure 3a.1).

Health consciousness scale

An additional questionnaire on health attitudes was analysed in this study to further explore the role of health motives in the three consumer groups. Health consciousness assesses the degree to undertake health actions and was operationalised by the health consciousness scale on anchored line scales (Oude Ophuis, 1989; Schifferstein & Oude Ophuis, 1998). In this study, the Dutch version of the 11-item health consciousness scale was rated on a 5-point scale (ranging from 'totally disagree' to 'totally agree') by the subset of DNFCS respondents (Figure 3a.1).

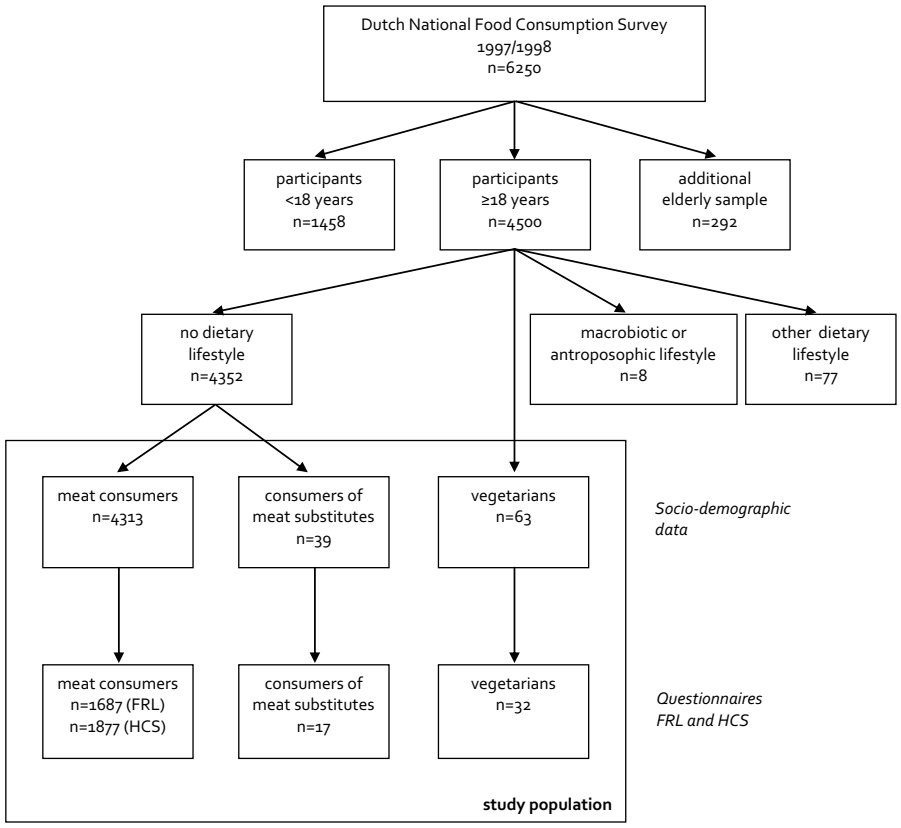

Figure 3a.1: Scheme of the study population taken from the Dutch National Food Consumption Survey 1997/1998
A 2-day food diary and personal data were taken from the study population. A selection of the respondents (lower row of boxes) also filled out the food-related lifestyle questionnaire (FRL) and health consciousness scale (HCS).

Data analysis

Gender was compared between the consumer groups by using a Pearson's X^2-test (pair wise), other categorical socio-demographic variables were rearranged into 3 ordinal classes for which X^2-tests for trend were used. One-Way ANOVA tests (2-tailed) with post-hoc tests (Games-Howell) were used to compare age and household size between consumers. Multivariate analyses of socio-demographic variables were performed by a logistic regression procedure with the forward stepwise method, in which the meat consumer group was taken as the reference group. In the logistic regression analysis the original classes from the socio-demographic variables were used. We excluded SES from regression analysis due to high correlation with education level (Pearson's $r = 0.62$).

The mean scores on the 23 dimensions of the food-related lifestyle instrument were compared between vegetarians, consumers of meat substitutes, and meat consumers by One-Way ANOVA (2-tailed) with post-hoc tests (Games-Howell). Respondents with missing values for one of the items in a scale were excluded from analysis. In addition, Cronbach α's were assessed as a measure of internal reliability.

A Principal Component Analysis with varimax rotation was run with the health consciousness scale, and mean scores on the derived factors compared between the consumer groups by One-Way ANOVA (2-tailed) with post-hoc tests (Games-Howell). All analyses were conducted with SPSS 10.0 statistical software and *p*-values below 0.05 were considered statistically significant.

3A.3 RESULTS

Socio-demographic characteristics

A comparison of socio-demographic characteristics showed a trend of both vegetarians and consumers of meat substitutes, towards smaller households, higher education levels, higher SES, and more urbanized residential areas, relative to meat consumers. In addition, the vegetarian group consisted of a higher percentage of women compared to meat consumers (Table 3a.1). The gender distribution between consumers of meat substitutes and meat consumers was not significantly different. Among vegetarians, there were 19 respondents (30%) who lived with a vegetarian housemate, while this applied for only 2 consumers of meat substitutes (5%).

Multivariate analyses indicated that gender ($\beta = 0.81$, $SE = 0.31$, $p < 0.009$), education ($\beta = 0.40$, $SE = 0.09$, $p < 0.001$), urbanization ($\beta = 0.38$, $SE = 0.12$, $p < 0.002$), and household size ($\beta = -0.37$, $SE = 0.12$, $p < 0.003$) were the predictors of being a vegetarian. (Goodness of Fit $X^2(8) = 4.92$, $p = 0.77$). Being a meat substitute consumer was predicted by the degree of urbanization ($\beta = 0.72$, $SE = 0.18$, $p < 0.001$), household size ($\beta = -0.40$, $SE = 0.16$, $p < 0.02$) and education ($\beta = 0.38$, $SE = 0.11$, $p < 0.001$) (Goodness of Fit $X^2(8) = 5.42$, $p = 0.71$).

Food-related lifestyle instrument

Vegetarians scored significantly higher for items concerning *importance of product information, speciality shops, health, novelty, ecological products, social event,* and *social relationships* than meat consumers. *Woman's task* was rated lower by vegetarians than meat consumers (Table 3a.2). Compared to meat consumers, meat substitute consumers displayed higher scores on *price-quality relation* and lower scores on *woman's task. Social event* was less important to meat substitute consumers than vegetarians, while *price quality relations* was more important to them. It must

be noted that in this Dutch sample a number of food-related lifestyle dimensions had internal consistency values below 0.60 (Table 3a.2).

Health consciousness scale

Two factors were extracted from the Principal Component Analysis, largely corresponding to earlier description by Schifferstein & Oude Ophuis (1998) as *health sacrifice and health occupied* (Table 3a.3). The higher scores of vegetarian consumers for *health occupied* were found significantly different from meat consumers, $F(2,1921) = 3.32$, $p < 0.04$. Meat substitute consumers did not differ in health consciousness from meat consumers.

Table 3a.1: Socio-demographic characteristics of the study population: vegetarians, consumers of meat substitutes and meat consumers

Socio-demographic characteristics		Vegetarians (n=63)	Consumers of meat substitutes (n=39)	Meat consumers (n=4313)
Gender (% of women)		73[a]	59	54[a]
Age (years)		41.1 (14.8)	39.2 (14.8)	42.4 (14.8)
Household size (persons)		2.2 (1.2)[b]	2.1 (1.1)[c]	3.0 (1.4)[bc]
Education level	% low	19[d]	18[e]	44[de]
	% medium	34[d]	26[e]	34[de]
	% high	47[d]	55[e]	22[de]
Household income	% low	41	43	44
	% medium	42	40	37
	% high	17	17	20
Social Economic Status	% low	13[f]	21[g]	40[fg]
	% medium	41[f]	28[g]	21[fg]
	% high	46[f]	51[g]	38[fg]
Urbanization level	% low	10[h]	8[i]	18[hi]
	% medium	19[h]	13[i]	42[hi]
	% high	71[h]	80[i]	40[hi]

Age and household size values are mean (*SD*).

[a]vegetarians versus meat consumers, $X^2(1)= 9.13$, $p < 0.004$.

[b]vegetarians versus meat consumers, [c]meat substitute consumers versus meat consumers, $F(2,4412) = 18.68$, $p < 0.0005$.

[d]vegetarians versus meat consumers, $X^2(1) = 25.15$, $p < 0.0005$.

[e]meat substitute consumers versus meat consumers, $X^2(1)= 21.87$, $p < 0.0005$.

[f]vegetarians versus meat consumers, $X^2(1) = 9.78$, $p < 0.003$.

[g]meat substitute consumers versus meat consumers, $X^2(1) = 5.22$, $p < 0.03$.

[h]vegetarians versus meat consumers, $X^2(1) = 19.15$, $p < 0.0005$.

[i]meat substitute consumers versus meat consumers, $X^2(1)= 18.49$, $p < 0.0005$.

Table 3a.2: Food-related lifestyle attitudes of vegetarians, consumers of meat substitutes, and meat consumers

Food-related lifestyle attitudes	Cronbach α	Vegetarians (n=32)		Consumers of meat substitutes (n=17)		Meat consumers (n=1638)	
		Mean	*SD*	Mean	*SD*	Mean	*SD*
Ways of shopping							
Importance of product information	0.78	4.5[a]	0.9	4.6	1.5	3.8[a]	1.3
Attitude towards advertising	0.52	2.7	1.1	3.0	1.5	3.2	1.1
Enjoyment from shopping	0.53	4.2	1.1	4.5	1.4	4.0	1.2
Speciality shops	0.51	4.0[b]	1.1	3.5	1.2	3.3[b]	1.2
Price criteria	0.70	4.2	1.2	5.0	1.4	4.5	1.4
Shopping list	0.59	4.9	1.1	4.3	1.3	4.6	1.4
Quality Aspects							
Health	0.82	5.4[c]	1.2	4.4	1.7	4.0[c]	1.4
Price quality relation	0.58	4.7[d]	0.7	5.5[de]	0.7	4.9[e]	1.1
Novelty	0.72	4.7[f]	1.2	4.5	1.2	4.1[f]	1.4
Ecological products	0.80	4.8[g]	1.6	3.7	1.9	3.0[g]	1.3
Taste	0.52	4.6	1.0	4.4	0.8	4.8	0.9
Freshness	0.75	5.8	0.9	5.3	1.1	5.5	1.2
Cooking methods							
Interest in cooking	0.71	3.5	1.4	3.9	1.4	3.5	1.4
Looking for new ways	0.88	4.5	1.6	4.4	1.6	3.9	1.6
Convenience	0.65	2.4	1.1	2.9	1.6	2.7	1.2
Whole family	0.38	4.3	1.1	3.4	0.8	4.1	1.2
Planning	0.50	3.5	1.5	3.5	1.5	3.6	1.2
Woman's task	0.74	1.9[h]	1.0	2.0[i]	0.8	3.0[hi]	1.5
Consumption situation							
Snacks versus meals	0.51	2.3	0.7	2.3	0.8	2.2	0.9
Social event	0.59	3.9[jk]	1.3	2.4[j]	1.7	3.0[k]	1.3
Purchasing motives							
Self-fulfilment in food	0.63	4.3	1.3	3.9	1.1	4.2	1.2
Security	0.60	3.3	1.3	3.3	1.3	3.7	1.2
Social relationships	0.63	5.1[l]	0.7	4.9	1.1	4.5[l]	1.2

Sumscores of scales were divided by number of items, items were rated on 7-point scales ranging from 'totally disagree' to 'totally agree'.

[a]vegetarians versus meat consumers, $F(2,1659) = 7.32$, $p < 0.002$.

[b]vegetarians versus meat consumers, $F(2,1663) = 5.32$, $p < 0.006$.

[c]vegetarians versus meat consumers, $F(2,1663) = 13.06$, $p < 0.0005$.

[d]vegetarians versus meat substitute consumers, e meat substitute consumers versus meat consumers, $F(2,1671) = 3.09$, $p < 0.05$.

[f]vegetarians versus meat consumers, $F(2,1651) = 3.32$, $p < 0.04$.

[g]vegetarians versus meat consumers, $F(2,1671) = 33.42$, $p < 0.0005$.

[h]vegetarians versus meat consumers, imeat substitute consumers versus meat consumers, $F(2,1660) = 11.59$, $p < 0.0005$.

[j]vegetarians versus meat substitute consumers, kvegetarians versus meat consumers, $F(2,1671) = 7.90$, $p < 0.0005$.

[l]vegetarians versus meat consumers, $F(2,1667) = 3.86$, $p < 0.03$.

Table 3a.3 Health consciousness of vegetarians, consumers of meat substitutes, and meat consumers

	Factor 1 Health sacrifice	Factor 2 Health occupied
Eigenvalue	5.2	1.2
Cronbach α	0.89	0.72
Percent of variance (%)	36	22
Vegetarians (n=32)	3.4 (0.6)	3.2 (0.6)[a]
Consumers of meat substitutes (n=17)	3.3 (0.9)	3.0 (0.7)
Meat consumers (n=1877)	3.2 (0.7)	2.9 (0.7)[a]

Values are indicated as mean (*SD*), items were rated on five-point scales ranging from 'totally disagree' to 'totally agree'.
Items factor 1: I consider myself very health conscious; I think it is important to know well how to eat healthy; My health is so valuable to me, that I am prepared to sacrifice many things for it; I think that I take health into account a lot in my life; I have the impression that I sacrifice a lot for my health; I often dwell on my health*; I am prepared to leave a lot, to eat as healthy as possible.
Items factor 2: I really don't think often about whether everything I do is healthy [R]; I do not continually ask myself whether something I do is healthy [R]; I don't want to ask myself all the time, whether the things I eat are good for me [R]; I have the impression that other people pay more attention to their health than I do* [R].
[R] Items were reversed for analysis.
*Schifferstein and Oude Ophuis (1998) reported these items loading on the opposite factor.
[a]Significant difference between vegetarians and meat consumers.

3A.4 DISCUSSION

The socio-demographic profile of vegetarians: predominantly women, highly educated, high SES, small households, and urbanized residential areas, was largely consistent with previous findings (Fraser, Welch, Luben, Bingham, & Day, 2000; Freeland-Graves et al., 1986; Perry et al., 2001). Consumers of meat substitutes had similar socio-demographic characteristics, apart from the higher number of women. It has been stated that women are the main users of these products (McIlveen, et al., 1999). However, the ratio of male/female non-vegetarian consumers of meat substitutes was found almost equal in the representative sample we used for this study. This implicates that for a thorough description of socio-demographic characteristics of consumers of meat substitutes it is useful to distinguish vegetarian from non-vegetarian respondents.

Differences in food-related lifestyle attitudes between vegetarians and meat consumers were dispersed among the 5 aspects of food-related lifestyle: *ways of shopping, quality aspects, cooking methods, consumption situations, and purchasing motives.* Vegetarians had positive attitudes towards shopping in speciality shops and a high preference for ecological products, which was in line with our expectations. Health was more considered an important quality aspect by vegetarians than meat consumers, which was also supported by the health consciousness questionnaire. Furthermore, vegetarians paid a higher attention to product information labels and were more interested in new food products and new recipes. The importance of

social aspects in eating was reflected in the purchasing motive to reinforce social relationships, but also regarding consumption situations: vegetarians seem to prefer to eat together with friends. Vegetarians did obviously not feel that the kitchen is a woman's domain, which can probably be explained by the large proportion of females in the vegetarian group.

Non-vegetarian meat substitute consumers appeared to be less distinguishing in food-related lifestyle attitudes compared to vegetarians, and took an intermediate position for most dimensions. Despite the small sample size of this consumer segment, the higher importance attached to price/quality, lower interest in social aspect of meals, and more feminist view with respect to food preparation were remarkable. One might have expected a higher attention of these consumers to health, ecological products or speciality shops, but this was not observed in our study. Janda & Trocchia (2001) have described vegetarian oriented consumers as individuals who do not consider themselves vegetarians, but prefer greater vegetarian options relative to meat-based choices. In line with the results presented here, vegetarian oriented consumers were found to be much more similar, in terms of concern for the environment, to non-vegetarians than strict vegetarians. However, Janda & Trocchia (2001) did show a higher involvement of these consumers in nutritional health aspects.

Definite personal values expressed in food choice, such as ecological ideologies, are reported typical for vegetarians (Lindeman & Sirelius, 2001). Food-related lifestyle can be seen as a means of people to use food to achieve these personal life values (Brunsø, Scholderer, & Grunert, 2004). Although the meat avoiding behaviour of non-vegetarian consumers of meat substitutes resembles that from vegetarians, they do not seem to hold strong ideologies, given that their food-related lifestyle attitudes did not differ from meat consumers' attitudes to a great extent.

The study described in this chapter has a number of limitations. First of all, we used data from a survey that had been collected previously. The two consumer segments of interest, vegetarians and non-vegetarian consumers of meat substitutes, were not well represented in the overall sample. The proportion of vegetarians was around 1%, which is low compared to other survey data such as 4% in the U.K. (British Nutrition Foundation, 1995). We think that due to different descriptions used for the term 'vegetarian' these figures can vary substantially . Moreover, some vegetarian consumers do eat meat occasionally (Barr & Chapman, 2002). The definition used in this study was based on 'eating meat less than once a week', which could have resulted in a relatively low percentage of vegetarians. These small numbers of vegetarians and consumers of meat substitutes could have simplified the interpretation of the results, particularly with the description of food-related lifestyle and health attitudes of the subsample. Despite this, the illustrated attitudes of vegetarians were quite consistent with previous reports. In addition the data was taken from a large representative food

consumption survey. We therefore think that this study still provides some valuable insights of these Dutch consumer groups in 1997/1998. It is well possible that there was some misclassification of consumers, since vegetarians were identified by means of self-reporting of dietary lifestyle and non-vegetarian consumers of meat substitutes were identified on the basis of consumption of a meat substitute product during the recording period. One of the disadvantages of a two-day food diary is that it does not reflect long-term intake (Buzzard, 1998). Our classification included at least the individuals who were familiar with the use of meat substitutes. Although it might still be possible that there are subjects in the meat consumer group who consume meat substitutes on a regular basis. The method used to assess attitudes to food was the food-related lifestyle questionnaire, which had successfully been applied to European food cultures: Denmark, Great Britain, France and Germany (Bredahl & Grunert, 1998; Brunsø & Grunert, 1998; Grunert et al., 1997). We found that some of the food-related lifestyle scales had fairly low reliabilities in the Dutch sample. For the purpose of this study, we decided to maintain the structure of the questionnaire (23 lifestyle dimensions in 5 domains) in order to make comparisons between the different consumer groups for the various attitudinal aspects with respect to food. The data used for this study was collected in 1997 and 1998. The increase in market share of vegetarian products has often been associated with food crises, e.g. BSE, foot and mouth disease, which occurred successively from 1998 - 2000. A recent report from the Netherlands (Aurelia, 2002) indicates that concerns about meat are not an important motive to buy meat substitute products; therefore we think our study is still relevant.

The term 'vegetarian' is ambiguous, and there have been debates on how to use it, either as a typical food behaviour (e.g. avoiding meat) or as an ideology (e.g. caring for animals). It has even been proposed to remove the term completely from scientific literature (Weinsier, 2000). With the rising number of people with an interest in vegetarian diets, several new terms are introduced such as part-time vegetarian, semi or demi-vegetarian, pseudo-vegetarian, or vegetarian-oriented consumer, which essentially seem to have the same meaning (British Nutrition Foundation, 1995, Janda et al., 2001, Silverstone, 1993, Worsley & Skrzypiec, 1998). The concept of vegetarianism is thus broadening. In another study we will therefore study the attitudes and motives of consumers with different levels of replacement of meat by vegetable based products (Chapter 3b). A significant decrease in meat consumption by Novel Protein Foods can only be reached when consumer wishes for meat substitute products of these various segments are identified and understood.

In sum, although the socio-demographic profile of meat substitute consumers was comparable to those from vegetarians, they did not have the same attitudes towards food. Vegetarians considered ecological and health themes in relation to food important, while this was not observed at non-vegetarian meat substitute consumers.

We suggest that for a wider acceptance of meat substitutes, these products should not rely exclusively on ethical or health claims.

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Chapter 3b

Replacement of meat by meat substitutes: A survey on person- and product-related factors in consumer acceptance

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ABSTRACT

What does it take to increase the consumption of meat substitutes and attract new consumers? We identified main barriers and drivers by a consumer survey (n = 553) in the U.K. and the Netherlands. Person-related factors (food neophobia and food choice motives) and product-related attitudes and beliefs towards meat and meat substitutes were compared between non-users (n = 324), light/medium-users (n = 133) and heavy-users of meat substitutes (n = 96). Overall, consumer acceptance was largely determined by the attitudes and beliefs towards meat substitutes and food neophobia. Key barriers for non-users and light/medium-users were the unfamiliarity with meat substitutes and the lower sensory attractiveness compared to meat. In addition, non-users had a higher tendency to avoid new foods. Hence, the less consumers were using meat substitutes, the more they wanted these products to be similar to meat. Although non-users and light/medium-users did recognize the ethical and weight-control aspects of meat substitutes, this was obviously less relevant to them. Actually, only heavy-users had high motivations to choose ethical foods, which explains their choice for meat substitutes. In order to make meat substitutes more attractive to meat consumers, we would not recommend to focus on communication of ethical arguments, but to significantly improve the sensory quality and resemblance to meat.

3B.1 INTRODUCTION

Developing new food products that are attractive to consumers is a challenge (Costa & Jongen, 2006; Stewart-Knox & Mitchell, 2003; Van Trijp & Van Kleef, 2008). However, it is even more complex when these new foods are meant as a substitute for products that are highly appreciated, like meat (Wansink, Sonka, Goldsmith, Chiriboga & Eren, 2005). This challenge is faced by researchers and developers of new sustainable meat substitutes that need to reduce the negative environmental impact of industrial-scale meat production for human consumption. (Aiking, De Boer, & Vereijken, 2006; Helms, 2004; Jongen & Meerdink, 2001). A consequence of this environmental objective is that the focus is not only on consumer acceptance of meat substitutes in itself, but also on the potential of these products to actually replace meat in a meal. These new meat substitutes are thus not intended for vegetarians but need to attract new consumers, namely current meat consumers, and ought to facilitate meat avoiders to decrease their consumption of meat even further. To generate input for product development and promotion strategies to increase consumption of meat substitutes, more insight is needed on drivers and barriers among different consumer groups to use these products.

Meat substitutes: the state of affairs

Meat substitutes, also referred to as meat replacers, meat alternatives, or meat analogs (Davies & Lightowler, 1998; Kuntz, 1995; McIlveen, Abraham, & Armstrong, 1999; Sadler, 2004), are primarily vegetable based food products that contain proteins made from pulses (mainly soy), cereal protein, or fungi. There was a sharp increase in the consumption of these products around 2001 after a number of food safety crises (B.S.E., food and mouth disease) in the meat sector in the Netherlands (De Steur, 2001; PVE, 2003; Sadler, 2004). Soon after that period, the growth in the market stabilized (PVE, 2004) and sales of organic meat substitutes even decreased (Biologica, 2006). In fact, the quantity of consumed meat only slightly decreased (-2%) over the years 2000 to 2008 (Centraal Bureau voor de Statistiek, 2008). Market shares of meat substitutes are estimated at no more than 1-2% of the total Dutch meat market (Anonymous, 2004). Besides the quantity, also the frequency of consumption of meat substitutes is low. Meat is consumed 3 times a week or more by 80% of Dutch consumers in contrast to meat substitutes that are used by most meat substitute consumers only one or two times a week or even less (Aurelia, 2002). The difficulty with establishing a broad acceptance of meat substitutes is probably related to several aspects. Firstly, these types of products are relatively new. Soy products, such as tofu & tempeh, appeared on the Western market in the sixties, while other meat substitutes (e.g. Tivall and Quorn) were introduced around 25 years ago or less (Davies & Lightowler, 1998; McIlveen

et al., 1999; Sadler, 2004). Even new sources of protein have been applied, such as mycoprotein for the product Quorn (Peregrin, 2002). Secondly, a large difference in the perceived product quality of meat and meat substitutes is likely to play an important role. Both experience quality attributes such as convenience, freshness, and sensory characteristics, and credence quality attributes (e.g. healthiness) are important for consumer's buying behaviour of meat. Meat is especially appreciated for its sensory properties, its unique taste and texture (Grunert, Bredahl, & Brunsø, 2004; Issanchou, 1996). A few studies investigated consumers' evaluation of both meat and meat substitutes and found that meat substitutes stayed behind in overall evaluation and in particular the sensory appreciation, but also on other attributes such as price and luxury (Aiking et al., 2006; McIlveen, Abraham, & Armstrong, 2001; Van Der Lans, 2001; Van Trijp, 1991). However, meat substitutes did score higher on animal and environmental friendliness attributes compared to meat (Van Der Lans, 2001). Meat substitute products are currently primarily aimed and used by vegetarians and semi-vegetarians and have a strong emphasis on health and ethical quality aspects (Hoek, Luning, Stafleu, & de Graaf, 2004; Janda & Trocchia, 2001; McIlveen et al., 1999; Kuntz, 1995; Sadler, 2004).

In short: there seem to be a discrepancy between meat and meat substitutes with respect to the frequency of use, degree of newness, product quality attributes, and their types of consumers.

Theoretical background and framework of the study

There are two approaches from different fields that can be used to obtain more insight how to increase the usage frequency of certain products: usage segmentation and the Stages of Change model.

Usage segmentation uses behavioural variables (e.g. brand usage, product category usage, product usage) as a means to construct market segments. Consumers are divided in segments according to their level of use or user status, such as heavy-users, medium-users, light-users, and non-users. The advantage of this approach is that it differentiates actual product usage, as opposed to psychographic segmentation that groups consumers based on personality and lifestyle (Kotler, Armstrong, Saunders, & Wong, 1999; Assael, 1995; Weinstein, 2004). The profiles of light and non-users are especially worthwhile to investigate further, because they are what heavy-users used to be (Wansink, Sonka, & Park, 2001). Companies target consumers by usage category in order to increase consumption and thereby 'move them up the usage ladder' (Weinstein, 2004).

From the health-related behavioural field, there is a model that considers changes in (consumption) behaviour over time: the Stages of Change model (Prochaska & DiClemente, 1982; Prochaska & DiClemente, 1983; Prochaska, DiClemente, &

Norcoss, 1992). Prochaska and others proposed that change occurs through a series of stages or also referred to as a sequence of cognitive and behavioural steps (Kristal, Glanz, Curry, & Patterson, 1999): precontemplation (unaware, not interested in change); contemplation (thinking about changing); decision or preparation (making definite plans to change), action (actively modifying behaviour) and maintenance (maintaining the new, favourable behaviour). In relation to eating behaviour, these stages correspond with the balance between the perceived benefits and barriers to change one's diet. The model has been used to describe behaviour towards a healthier diet, mostly on an increase in fruit and vegetable consumption or a reduction in fat intake - see the review by Spencer, Wharton, Moyle, & Adams (2007). The practical implication of this model is that these processes of change can guide intervention programs or communication strategies that are stage-matched, which means they are specifically designed to match the cognitive/behavioural state of individuals in a certain stage of change (Kristal et al., 1999).

We used the key characteristics of the approaches described above as a framework for a study to identify underlying drivers and barriers in consumer acceptance of meat substitutes, which is illustrated in Figure 3b.1. A basic element was that the degree of consumer acceptance is indicated by current consumption behaviour, which was used for segmentation. Individuals were assigned to one user group according to their usage of the product category meat substitutes (non-users, light/medium-users, and heavy-users). Secondly, we assumed that there is a temporal pattern: heavy-users changed from non- to light/medium-users over time. Thirdly, the movement to another acceptance level is under influence of particular drivers and barriers, which differ between the different levels of acceptance. We hypothesized that these drivers and barriers are factors related to the personal influences on the choice of certain foods in general, such as food neophobia and food choice motives, and factors related to the product namely attitudes and beliefs specifically towards meat and meat substitutes (Table 3b.1). The expected role of each of these factors is briefly discussed below.

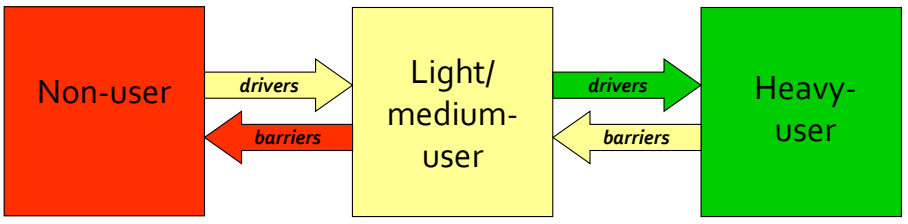

Figure 3b.1: Study framework
The scheme displays three user groups with respect to the degree of consumption of meat substitutes. Drivers and barriers can be at the level of person-related factors (food neophobia or food choice motives) and product-related attitudes and beliefs.

Food neophobia is the tendency to avoid new foods and was conceptualized by Pliner & Hobden (1992) as a personal trait that can be quantified by the food neophobia scale (FNS). Several studies have shown that it is related to the extent in which consumers accept new and/or unusual foods (e.g. Henriques, King, & Meiselman, 2009; Olabi, Najm, Baghdadi, & Morton, 2009; Raudenbush & Frank, 1999; Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001). Since meat substitutes are relatively new products on the market, we expected that especially food neophobia acts as a barrier on the first trial with meat substitutes, in other words that current non-users would be relatively highly food neophobic (Table 3b.1). We assumed that food neophobia would not act as a major barrier on light/medium-users to increase their consumption of these products further because previous consumption generally has a positive effect on acceptance (Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994; Pliner, Pelchat & Grabski, 1993; Raudenbush & Frank, 1999).

Food choice motives, i.e. the importance that individuals attach to factors such as health, price, sensory appeal and convenience, are also of influence in the choice for certain foods (Pollard, Steptoe, & Wardle, 1998; Steptoe, Pollard & Wardle, 1995). There are few studies available in the public domain that have assessed food choice motives specifically with respect to meat substitutes, but there are publications on comparable moderate shifts in the diet, like semi-vegetarianism, eating less red meat, eating a plant-based diet, and so on. There are usually multiple motives behind these types of dietary choices, such as a higher interest in health, weight control and the natural content of foods, and a higher concern for animal welfare and environmental issues. In contrast, strict vegetarians seem to have less diverse reasons and are primarily motivated by compassion for animal welfare and the environment (Hoek et al., 2004; Janda & Trocchia, 2001; Lea, Crawford, & Worsley, 2006; Lindeman & Sirelius, 2001; Lindeman & Väänänen, 2000; Pollard et al., 1998; Santos & Booth, 1996). Based on these findings we hypothesized that initial drivers to become a light/medium-user of meat substitutes would be a greater importance attached to the food choice motives health, natural content, weight control and ecological welfare (includes animal welfare and environmental issues), see Table 3b.1. Heavy-users of meat substitutes would probably be more dissociated from meat, alike vegetarians. We therefore expected that a high interest in ecological welfare with respect to foods would be a strong driver to increase consumption of meat substitutes towards heavy usage.

Particular motives can also act as barriers on the acceptance of meat substitutes. Verbeke & Vackier (2004) described how some meat consumers are mainly hedonic-oriented when making food consumption decisions. In general, meat lovers seem to be largely driven by sensory aspects, a sense of tradition, and less by a concern about methods of meat production (Grunert, 1997; Issanchou, 1996; Richardson, Shepherd, &

Elliman, 1993; Verbeke & Vackier, 2004). Based on this information and an explorative study (unpublished results), we expected that a higher interest in sensory appeal, price and familiarity in food choice would be major barriers for non-users to become light/medium-users of meat substitutes (Table 3b.1). The influence of other food choice motives on the acceptance of meat substitutes, such as mood, convenience, and political values, were investigated as well.

Besides the general personal factors food neophobia and food choice motives, product-related attitudes and beliefs towards meat and meat substitutes are likely to play a role in the choice for these products. The attitude towards a product becomes more or less favourable depending on how well product attributes match consumers' goals. The choice between alternatives (i.e. meat or meat substitutes) will subsequently be determined by the beliefs about these products and the trade-off between the positive and negative consequences consumers expect after buying (Brunsø, Scholderer, & Grunert, 2004; Grunert et al., 2004; Kotler et al., 1999). In the previous section we described how meat attributes and meat substitute attributes are perceived to be different. We therefore assumed that a more positive attitude towards meat substitute attributes than meat attributes acts as a driver, and when this difference is even higher the consumption of meat substitutes can increase to heavy usage (Table 3b.1). Specific attitudes and beliefs might play a role between user groups: a more positive attitude towards sensory and health aspects of meat substitutes acting as a driver to progress from non-user to light/medium-user, while attributes related to ecological welfare might come into play from light/medium-users to heavy-users. The other way around, a more positive attitude towards meat attributes can act as a barrier. As for health for example, this is in line with previous findings that the perceived healthiness of meat predicts the degree of meat consumption (Lea & Worsley, 2001; Richardson et al., 1993). We thought that strong beliefs related to symbolic meanings of meat (e.g. power, masculinity) and being a central part of a proper meal (e.g. satiating power) (Allen & Baines, 2002; Fiddes, 1991; Holm & Møhl, 2000; Meiselman, 2000) would have a negative effect on acceptance of meat substitutes as well. In addition, more practical constraints would come up when products are actually used, such as the perceived convenience aspects of meat and a positive social influence of other household members to have meat for dinner. These might act as barriers to use meat substitutes more frequently among light/medium-users to become heavy-users.

When meat substitutes share certain attributes with meat they might be more attractive to certain consumers. Tuorila et al. (1994) suggested that there is positive bias to the familiar and that resemblance to a more familiar food increases liking. Conversely, individuals who avoid the consumption of meat might have a higher tendency to dislike products that are similar or remind them to meat (Fessler, Arguello, Mekdara,

& Macias, 2003; Rozin, Markwith, & Stoess, 1997). We therefore wanted to explore whether persons who are more positive about meat and its attributes would prefer meat substitutes that are more similar to meat and vice versa. We expected that light/medium-users would like to see meat-like product characteristics in a meat substitute, while heavy-users would prefer meat substitutes that are less similar to meat.

In summary, this chapter describes which drivers and barriers act on the acceptance of meat substitutes by comparing different user groups (non-users, light/medium-users and heavy-users of meat substitutes) for factors that affect food choice in general (personal influences food neophobia and food choice motives), and specifically the choice for meat or meat substitutes (product-related attitudes and beliefs).

Table 3b.1: Summary of hypothesized drivers and barriers to use meat substitutes more frequently

			Non-user to Light/Medium-user	Light/Medium-user to Heavy-user
Drivers →	Person-related	Food choice motives	High interest in health, ecological welfare and weight control	Particularly high interest in ecological welfare
	Product-related	Attitudes & beliefs	More positive about meat substitutes than meat, e.g. for health and sensory aspects	Much more positive about meat substitutes than meat, e.g. for sensory and ecological welfare aspects
Barriers ←	Person-related	Food Neophobia Food choice motives	Food neophobic High interest in sensory appeal, price and familiarity	
	Product-related	Attitudes & beliefs	Much more positive about meat than meat substitutes, e.g. for health, sensory, luxury aspects, satiety, 'power' image, and price	More positive about meat than meat substitutes, e.g. for convenience and social influence

3B.2 METHODS

We performed a cross-national consumer survey in two Western European countries with different acceptance levels of meat substitutes in order to obtain respondents with varying degrees of usage. The U.K. market for meat substitute products is considered one of the most developed in the world. For example, Quorn was introduced first in the UK and more than 5 years later available in other Western European countries (Sadler, 2004), such as the Netherlands. We therefore selected the United Kingdom (UK), with a relatively high acceptance of these products and the Netherlands (NL), having a lower level of acceptance. This approach offered the possibility to compare countries and different user groups within countries for the factors put forward that could play a role in replacement of meat by meat substitutes.

Respondents

Table 3b.2 gives an overview of the recruitment scheme of this study. Respondents were recruited at supermarket exits in cooperation with a marketing agency in 2003. Several supermarkets were selected to obtain a sample reflecting consumers that shop at different chains of supermarkets with varying price range in both cities and smaller towns. Most of the questionnaires -80%- were distributed in the cities. Across weekdays, weekend days and at different points in time, respondents were personally asked to fill out a questionnaire entitled 'Eating habits and Eating preferences' at home. Some of the respondents (19% of total sample) also participated anonymously in a short oral survey about meat substitutes performed by the marketing agency (results not described in this study). Finally, 235 English and 318 Dutch questionnaires were returned to the research team. Differences in response rates can probably be explained by the fact that Wageningen University is a very well known university in the Netherlands and obviously less known by the public in the U.K. Each respondent received an incentive of a national lottery ticket (equals ± 3 euro) after sending back the questionnaire.The obtained consumer samples from the UK and the Netherlands were comparable for socio-demographic characteristics, although Dutch consumers were somewhat higher in age and had more children (Table 3b.3).

Based on information about the frequency of use of meat substitute products (Aurelia, 2002), respondents were classified into three categories of user status within each country: non-users (meat substitute consumption categories: never; tried it once), light/medium-users (meat substitute consumption categories: less than once per month; once per month or more, but less than once per week), and heavy-users (meat substitute consumption categories: once a week or more). Although vegetarians were not our primary interest with regard to the background of this research, in some of the analyses this group was taken separately to examine if non-vegetarian users of meat substitutes were driven by the same motives or shared other characteristics (Hoek et al., 2004). In order to avoid diverse interpretations of the term 'vegetarian' with respect to the omission of different types of meat and other animal food sources in the diet, this was not specifically stated as a dietary lifestyle question within this survey.

Table 3b.2: Recruitment scheme for respondents

	United Kingdom	The Netherlands
Cities	Bristol	Amersfoort
Towns	Tetbury	Soest, Veghel
Supermarkets	Tesco, Somersfield, ASDA, Sainsbury's, Safeway, Waitrose	Albert Heijn, C1000, Lidl Super de Boer, Edah, Jumbo, Aldi
Distributed questionnaires	1500	750
Returned questionnaires (response rate)	253 (16%)	318 (42%)

Table 3b.3: An overview of the sample characteristics

		United Kingdom	Netherlands	Total sample
Sample size: n		235	318	553
Age: mean (*SD*)		40.9 (15.4)[a]	44.9 (14.6)[a]	43.2 (15.0)
Females: %		61.2	68.4	65.3
Household size: mean (*SD*)		2.8 (1.5)	2.9 (1.3)	2.8 (1.4)
Children in household: %	0	75.9[b]	61.1[b]	67.3
	1 or 2	19.3[b]	31.8[b]	26.6
	≥3	4.8[b]	7[b]	6.1
Education: %	low	4.3	8.3	6.6
	medium	28.3	25.9	26.9
	high	67.4	65.8	66.5

[a]significant difference in age ($t(1, 530) = -3.1$, $p < 0.003$).
[b]significant difference in percentage of children ($X^2(1, 542) = 10.5$, $p < 0.002$).

Vegetarians were identified on the basis of their frequency of meat consumption (as applied in Dutch Food Consumption surveys, see Hulshof, Kistemaker & Bouman, 1998): less than once a week (meat consumption categories: never; less than once a week).

We also used the stage algorithm as a means to combine current consumption rates with the length of time of a person's meat substitute consumption and the person's intentions for the future. As a first step to use the Stages of Change model for segmentation of consumers in relation to acceptance of meat substitutes, we used similar time frames to assess maintenance of the consumption behaviour (6 months) and future intentions (coming month and coming 6 months), as previously used in studies of dietary behaviour change (Kristal et al., 1999). The following five categories were derived: 1. precontemplators (current consumption of meat substitutes less than once a week and no intention to use these products more frequently), 2. contemplators (current consumption of meat substitutes less than once a week and intention to use these products more frequently in the coming 6 months, but not in the coming month), 3. consumers in preparation (current consumption of meat substitutes less than once a week and intention to use these products more frequently in the coming month), 4. consumers in action (current consumption of meat substitutes once a week or more, for less than 6 months), 5. consumers in maintenance (current consumption of meat substitutes once a week or more, for at least 6 months).

Questionnaire

The total questionnaire (127 items) consisted of several sections in the following order: Food Neophobia Scale (FNS), Food Choice Questionnaire (FCQ), Consumption of meat and meat substitutes, Attitudes and beliefs towards meat and meat

substitutes, Desired product characteristics, and Socio-demographic characteristics. Separate parts of the total questionnaire were previously tested by pilot studies. Translations were performed by a professional translation agency (AVB, Amstelveen, The Netherlands) using a translation and back translation procedure with different translators (FNS and FCQ translated from English to Dutch, self-developed parts from Dutch to English).

— Socio-demographic characteristics

  Based on previous studies (Hoek et al., 2004; Lea & Worsley, 2001), basic socio-demographic data were assessed that could be a factor in the substitution of meat in the diet: date of birth, sex, number of adults in household (aged 18 or older), number of children living at home (younger than 18), education level (6 classes from elementary education to polytechnic or university education), and address details.

— Consumption of meat and meat substitutes

  To avoid any ambiguity about the term 'meat'[1] and 'meat substitute'[2] this was specified prior to this section of the questionnaire. We also specified the type of meal at which these products are eaten, namely the main hot meal of the day, in order to exclude cold meat (substitute) products, such as those eaten with lunch. These products were not within the scope of this research. Enquiries were made about the respondents' usual consumption of meat and meat substitute products during the hot meal using the following answering categories for the frequency of meat consumption: never; less than once per week; once or twice per week; three or four times per week; five times or more per week. Categories used for the consumption of meat substitutes were: never; tried it once; less than once per month; once per month or more, but less than once per week; once or twice per week; three or four times per week, five times per week or more. Other questions related to consumption meat substitutes were: 'When did you start using meat substitutes?' (categories: less than one month ago; one to six month ago; six to twelve months ago; one to five years ago; five to ten years ago; ten or more years ago), 'Do you expect to eat meat substitutes more frequently during the coming six months?' (yes/no), 'Do you intend to eat meat substitutes more frequently during the coming month?' (yes/no).

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[1] *The term meat* refers to all meat products eaten during the main hot meal of the day, varying from steak and schnitzel to cubes of ham, pieces of bacon or minced meat in sauces. In this survey meat also includes poultry such as chicken or turkey, but not fish. It also does not include cold meat products used for sandwiches such as sausage or ham.

[2] *The term meat substitutes* refers to protein-containing foods that are primarily vegetable-based and that replace the function of meat as a meal component used for hot meals. Examples include vegetarian schnitzels, burgers, tofu, tempeh, and stir-fry products. These products can also be meal components in ready-made meals. It does not include fish, eggs, cheese, nuts or legumes.

— Food Neophobia Scale (FNS)
  The ten-item questionnaire developed by Pliner & Hobden (1992) was used to assess the trait food neophobia and rated on a 7-point scale ranging from 'strongly disagree' to 'strongly agree'.
— Food Choice Questionnaire (FCQ)
  As a measure for food choice motives, we used FCQ (Steptoe et al., 1995) supplemented with three scales on ethical food choice (Lindeman & Väänänen, 2000), due to the role of vegetarian or other ethical motives in the replacement of meat by meat substitute products. The motives assessed by the extended FCQ were: *health* (6 items), *mood* (6 items), *convenience* (5 items), *sensory appeal* (4 items), *natural content* (3 items), *price* (3 items), *weight control* (3 items), *familiarity* (3 items), *ecological welfare* (5 items), *political values* (4 items), and *religion* (2 items). The 44 items were prefaced by the statement: 'It is important to me that the food I eat on a typical day….' To be consistent with the other parts of the questionnaire, we used a 7-point scale ranging from 'strongly disagree' to 'strongly agree' (comparable to the categories described by Prescott et al., 2002) as an alternative for Steptoe's four categories ('not at all important' to 'very important'). Since texture[3] has not a commonly used equivalent in the Dutch language ('textuur') this was clarified in both the English and Dutch questionnaire.
— Attitudes and beliefs towards meat and meat substitutes
  Because we were particularly interested in the attitudes of consumers towards meat and meat substitutes, and not only in general food choice motives, we developed a 45-item questionnaire for this purpose. The topics of FCQ were rewritten towards product-specific statements. E.g. the FCQ item weight control 'It is important to me that the food I eat on a typical day is….. low on fat' was converted to 'These products are low in fat'. The ethical aspects (original FCQ scales *ecological welfare, political values and religion*) were combined into ethical, which were 3 items on animal friendliness, environmentally friendliness, and ethical production. We also extended the attitudes and beliefs items with the hypothesized aspects that might play a role in the acceptance of meat substitutes: *luxury* (e.g. 'These products are suitable for special occasions'), *social influence* (e.g. 'My fellow household members don't like to eat these products'), *power* (e.g. 'These products give me strength') and *satiety* (e.g. 'these products are not very filling'). Respondents without a fellow household member were allowed to skip the *social influence* items. In relation to *natural content*, one statement was included on genetic modification ('These products are

[3] The term texture refers to the characteristics you perceive when you have the food in your mouth and/or when you chew it. Examples include: hard, soft, crispy, granular, juicy, tough etc.

genetically modified') with an explanation of this term[4]. Each item was rated for both meat and meat substitutes on a 7-point scale from 'strongly disagree' to 'strongly agree', in order to determine the relative differences between meat substitutes and meat for all these different aspects. This enabled us to identify which characteristics of meat substitutes are perceived as positive or negative compared to meat, which might influence the level of consumer acceptance of meat substitutes.

— Desired new meat substitute attributes

To explore the degree of desired similarity to meat, we generated fourteen statements (semantic differential scales) that were rated after the question: 'What characteristics should a new meat substitute have for you to eat it with your hot meals on a regular basis?'. In addition, it was explicitly stated that respondents could indicate what they thought was desirable for them, and that ratings did not necessarily had to be based on existing meat substitute products. The statements reflected several intrinsic and extrinsic product attributes (one statement for each characteristic) based on qualitative pre-studies: Sensory attributes (anchored little-much similar to meat): texture, taste, appearance, and smell. Nutritive attributes (anchored less-more than meat): protein, calories, and vitamin & minerals. Extrinsic attributes and preparation (anchored little-much similar to meat): product name, preparation, and packaging. Extrinsic attributes (anchored less-more than meat): price, indicated shelf life, distance from meat display, and contents of the package.

Data analysis

Socio-demographic and consumption characteristics were compared across user groups and between the UK and the Netherlands by *t*-tests, ANOVA and X^2-tests. We investigated the correlation between meat consumption and meat substitute consumption with a Kendall's tau-b correlation coefficient. The validity of the FNS was explored by a free principal component analysis (varimax rotation) with reversed positive items. Two (UK) or three (NL) factors were derived, so unidimensionality could not be guaranteed for all the items. In the UK sample the first factor explained 42% of the variance and in the NL 33% of the variance. The internal consistencies for the ten items calculated were somewhat higher for the UK (Cronbach $\alpha = 0.84$) than for NL (Cronbach $\alpha = 0.76$). (Ratings for item 3 and 8 might be influenced by vegetarians who try to avoid animal substances, therefore we repeated the analyses with vegetarians excluded. This resulted in an improvement of the UK loadings (all on Factor 1) but did not result in any differences in the NL sample.) Since our samples were rather small and not representative samples, we did not have enough support to eliminate certain items and therefore we performed the analyses (*t*-tests, ANOVA)

[4] 'Genetically modified means that heriditary materials has been modified in order to change the characteristics of plants, animals, bacteria, fungi or yeasts' (Voedingscentrum).

with the total scores of the 10 items as an indicator of food neophobia. With respect to FCQ, factor loadings on the 11 factors were largely similar to the factors described by Lindeman & Sirelius (2001) and Pollard et al. (1998) for both country samples, and Cronbach α's were in general fairly high (0.55 to 0.91). The FCQ factors were compared between user groups and countries by ANOVA and *t*-tests. The internal structure of the self-developed product-related attitudes and beliefs questionnaire largely maintained after confirmatory factor-analysis, and Cronbach α's ranged from 0.43 to 0.79. Differences between user groups were investigated by ANOVA on relative scores (ratings for meat - ratings for meat substitutes, to illustrate gap between the two type of products). Finally, we constructed an overall regression model (CATREG) to predict the consumption level of meat substitutes, which explained 52% of the variance. The dependent variable was the degree of meat substitute consumption (non-users, light/medium-users, and heavy-users) and the independent variables were the total FNS score, the FCQ factors, the product-related attitudes and beliefs, and socio-demographic variables. We did not include interaction terms in the model. All analyses were conducted with SPSS 11.0 statistical software and *p*-values below 0.05 were considered statistically significant.

3B.3 RESULTS

Socio-demographic and consumption characteristics

In general, heavy-users of meat substitutes were a minority among the respondents, and there were more light/medium-users and heavy-users in the U.K. than in the Netherlands Vegetarians represented only a small portion of the samples (Table 3b.4). The heavy-user group contained 84% of the Dutch vegetarians while for the UK 46% of the vegetarians were in the heavy-user group. The most important difference in socio-demographic profile between user groups was the level of education: non-users were relatively lower educated than light/medium-users (UK: $X^2(1,185) = 3.9$, $p < 0.05$, NL: $X^2(1,264) = 4.0$, $p < 0.05$) and in the UK non-users had also a lower education than heavy-users ($X^2(1,148) = 5.0$, $p < 0.03$). Other socio-demographic characteristics of user groups were slightly different between the two countries: UK non-users (mean age 43.9 years) were older than light/medium-users (mean age 38.3 years) and heavy-users (mean age 38.7 years) ($F(2, 224) = 3.57$, $p < 0.04$). There were no significant differences in age between NL user groups. There were also more females (80.4%) among the UK heavy-users than in the non-user (54.8%) and light/medium-user groups (58.5%) ($X^2(2, 232) = 9.2$, $p < 0.02$). There were no differences in sex distribution between the NL user groups.

Table 3b.4: User groups and frequency of meat and meat substitute consumption

		Consumer group	UK	NL	Total sample
Sample size: n			253	318	553
Meat consumption: %	<1x per week	Vegetarians	10.3[a]	6.0[a]	7.8
	1-4x per week		61.5[a]	41.5[a]	50.0
	≥5x per week		28.2[a]	52.5[a]	42.2
Meat substitute consumption: %	never, seldom	Non-users	44.7[b]	68.9[b]	58.6
	<1x per week	Light/medium-users	35.3[b]	15.7[b]	24.1
	≥1x per week	Heavy-users	20.0[b]	15.4[b]	17.4

[a]significant difference in meat consumption between countries ($X^2(1, 552) = 28.8$, $p < 0.001$).
[b]significant difference in meat substitute consumption between countries ($X^2(1, 553) = 19.0$, $p < 0.001$).

We found that meat substitutes were actually used as a replacement of meat in the diet. Approximately one third of the heavy-users of meat substitutes ate meat less than once a week, while 74% of the respondents who ate meat 5 times per week or more, had never or rarely used a meat substitute. The replacement of meat by meat substitutes is also demonstrated by the inverse correlation of the consumption of meat vs. meat substitutes of –0.35 ($p < 0.001$) in the overall sample. The data also supported that acceptance of meat substitutes is a time-dependent process. 55% of heavy-users indicated that they started to use meat substitutes a long time ago (over 10 years) while 53% of light/medium-users started with these products until 5 years ago.

For the overall sample, the intention to use meat substitutes more frequently the coming 6 months was low among non-users (5% said yes). There was a difference between UK and NL, as NL respondents had a higher intention: in both the NL light/medium and heavy-users group, 45% of respondents said to intend using these products in the coming 6 months more frequently. The opportunities for the Dutch market becomes even more clear when current consumption, the period of use and future intentions are all combined to assign respondents according to stages of change (Figure 3b.2). The figure can be interpreted as follows: the UK sample consisted merely of two segments: 'precontemplators' who are not even considering to use meat substitutes, and 'maintainers' who are using these products frequently for over 6 months. NL shows a more dynamic picture in which a relatively high number of respondents (64%) were 'precontemplators', and some respondents were in the contemplation/preparation/action phase, which may ultimately lead to growth of the 'maintenance' group.

Food neophobia

In line with our expectations, we found that non-users of meat substitutes were more food neophobic than light/medium-users and that light/medium-users were not different from heavy-users with respect to food neophobia. Considering user groups

within countries, there were differences between user groups in the UK ($F(2,1229) = 3.2$, $p < 0.05$), caused by significant higher scores by non-users compared to light/medium-users (Figure 3b.3). The same trend was observed within the NL sample, although this was not statistically significant. Overall, we did not find a significant difference in food neophobia scores between the two country samples (UK mean FNS score 28.8, NL mean FNS score 29.1).

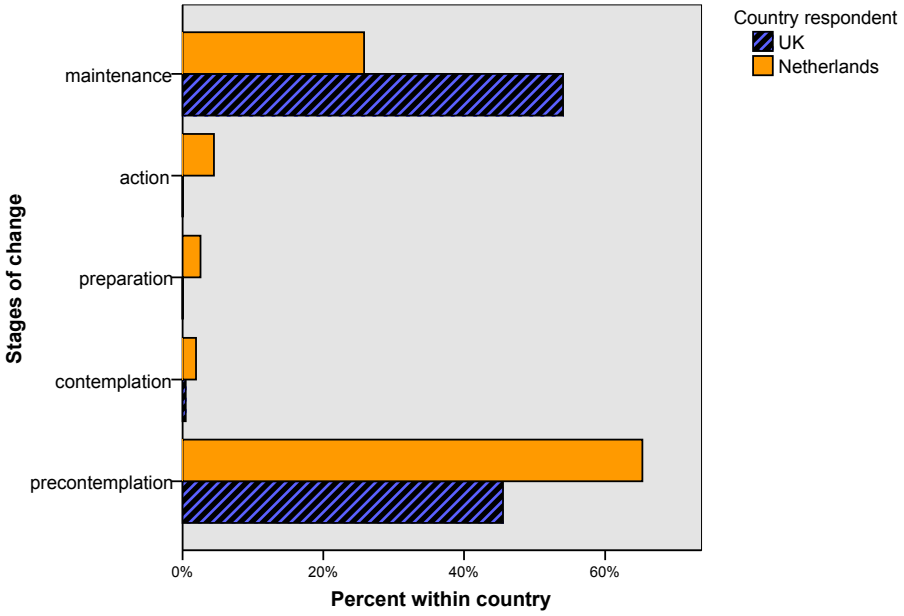

Figure 3b.2: Stages of change towards consumption of meat substitutes

Food choice motives

The largest differences in food choice motives were found between non-users and heavy-users; heavy-users gave higher ratings for *ecological welfare* (UK Δ0.6, $F(2,232) = 3.9$, $p < 0.0009$; NL Δ0.8, $F(2,311) = 8.5$, $p < 0.0003$) and *political values* (UK Δ0.6, $F(2,231) = 4.0$, $p < 0.002$; NL Δ0.7, $F(2,317) = 5.4$, $p < 0.006$) which is also shown in Figure 3b.4 (UK sample). In the UK, heavy-users even gave higher scores than light/medium-users for *ecological welfare* and *political values*, while in NL this was only the case for *political values*. Other differences between the groups were observed for *natural content* (higher scores by heavy-users than non-users in NL, higher scores by heavy-users than light/medium-users in UK), *familiarity* (more important to non-users than light-medium-users in UK and NL), *convenience* (light/medium-users gave lower scores than non-users and heavy-users in NL), and *sensory appeal* (more important to

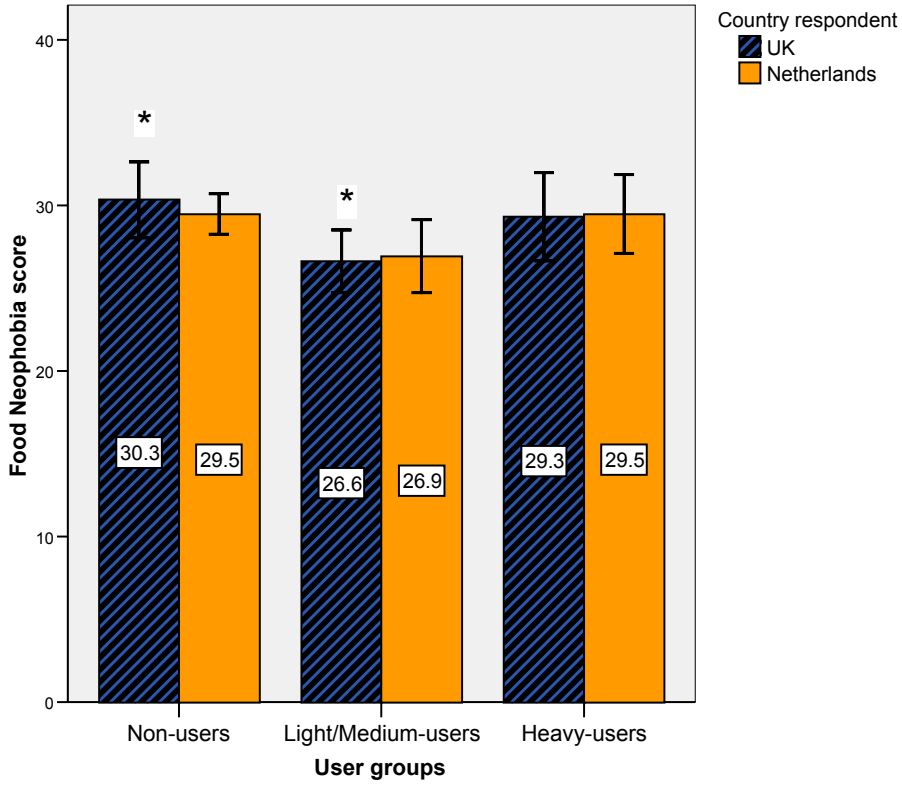

Figure 3b.3: Total food neophobia scores of non-users, light/medium-users and heavy-users of meat substitutes
Theoretical food neophobia score ranges from 10 (extremely food neophilic) to 70 (extremely food neophobic), items were rated on a 7-point scale.
*Significant difference between user groups.

non-users than light/medium-users in UK). When we excluded vegetarians from these analyses, the significant differences in importance of *ecological welfare* disappeared, and in the NL sample there was also no effect of political values left. The main differences were then between non-users and light/medium users; non-users found *convenience* and *familiarity* more important, and *natural content* less important, while light/mediums and heavy-users were less different from each other.

We also checked if there were any differences between food choice motives of the overall UK and NL sample. When we ranked the motives within each country sample, we found that in both UK and NL *sensory appeal* was the most important food choice motive and *health* the second important motive. However, *ecological welfare* was on average the third motive for UK respondents whereas *price* for NL respondents.

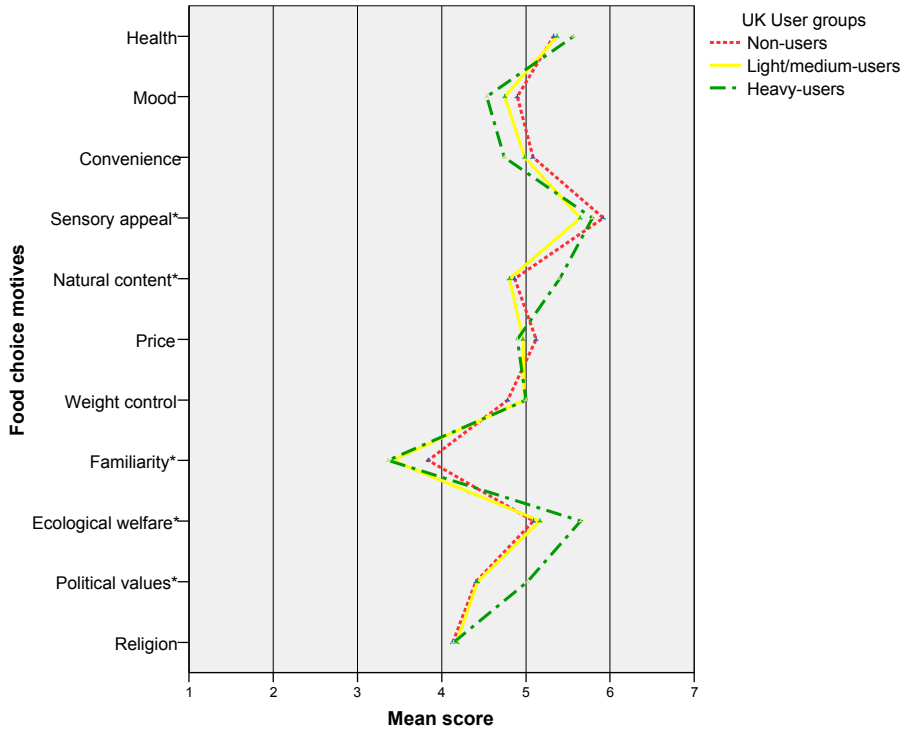

Figure 3b.4: Food choice motives of non-users, light/medium-users and heavy-users of meat substitutes in the U.K. *Significant difference between user groups.

Attitudes and beliefs towards meat and meat substitutes

Attitudes and beliefs towards meat and meat substitutes differed substantially between user groups (Figure 3b.5, NL sample shown). Bars that are in the positive area represent aspects that are seen as more positive for meat, while negative bars are seen as positive aspects for meat substitutes. There were significant differences for all rated aspects between user groups. In general, the picture shows that non-users had very positive attitudes and beliefs towards meat. They found meat products better for health and mood, more convenient, more sensory attractive, and more satiating. Particularly, non-users thought of meat as being more suitable for special occasions (*luxury*) and have a partner/housemate who likes meat (*social influence*). Meat substitutes only scored positive for *ethical* aspects and *weight control*. Light/medium-users displayed approximately the same positive and negative attitudes and beliefs as non-users, although they are slightly less in favour of meat. The picture changes radically when looking at scores from heavy-users who had a far more positive attitude towards most aspects of meat substitutes, except for the aspects *familiarity, luxury,*

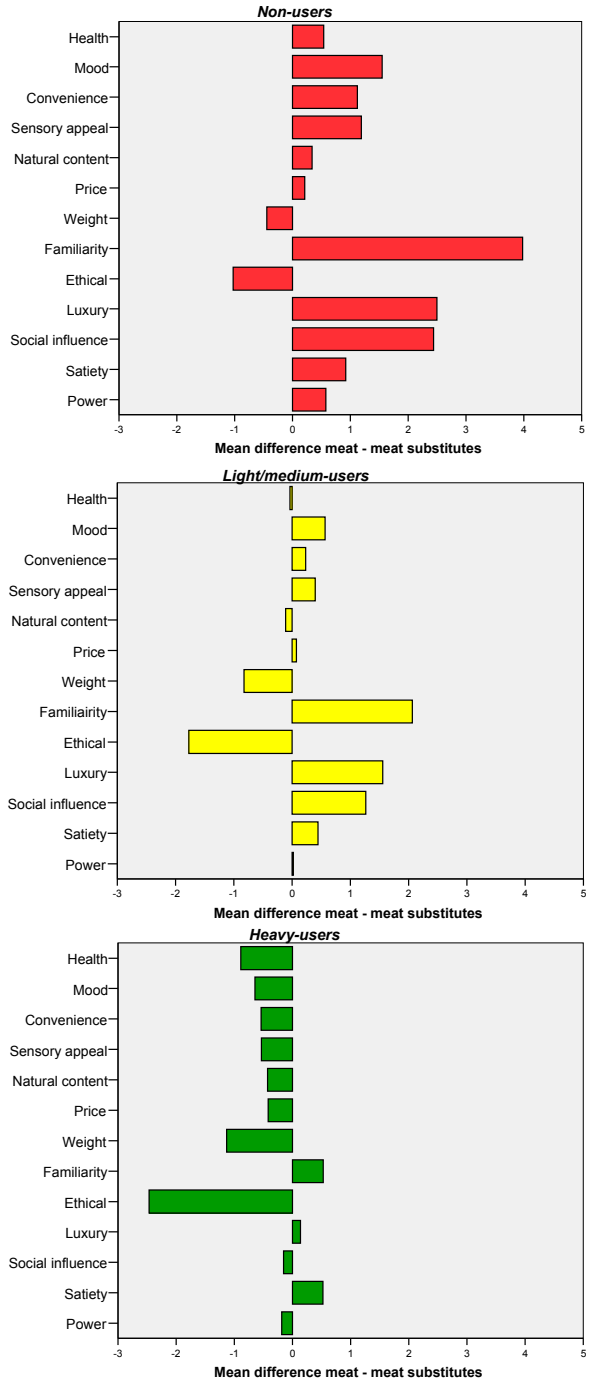

Figure 3b.5: Attitudes and beliefs towards meat substitutes relative to meat (NL user groups)
The theoretical range is -6 to 6. Items were scored on 7-point scales, for both meat and meat substitutes separately. Positive scores indicate a more positive attitude/belief towards meat, negative scores indicate a more positive attitude/belief towards meat substitutes.

and satiety. We did not find any significant differences between countries for attitudes and beliefs towards meat and meat substitutes.

Desired new meat substitute attributes

Figure 3b.6 clearly shows a trend that the less meat substitutes were consumed, the more respondents preferred a product that is similar to meat sensory properties. Those who rarely used meat substitutes indicated to prefer a product with meat-like texture, taste, smell and appearance. On the opposite, heavy-users of meat substitute preferred a product that is not similar to meat for these characteristics. (In the UK, a similar trend was observed). The same pattern was found for *product name, preparation* and *packaging*. Most respondents indicated to prefer a product with more protein, less calories and more vitamins & minerals than meat, independent from their usage of meat substitutes. There were also no differences between users for other product characteristics (shelf life, distance from meat display, and contents of the package) and most respondents indicated to prefer a product that has a lower price than meat.

Key factors in meat substitute acceptance.

Table 3b.5 displays the relative importance of the different factors in acceptance of meat substitute consumption. The most important determinant in the usage level of meat substitutes was familiarity with the product: perceived unfamiliarity with meat substitutes resulted in a lower usage frequency. Other strong barriers were high food neophobia and the belief that meat substitutes are less sensory attractive. A housemate/partner who is positive about meat substitutes and to a lesser degree the socio-demographic factors: living in the UK, a younger age and smaller household, contributed positively to a higher consumption of meat substitutes. After exclusion of vegetarians from these analyses the same picture emerged.

3B.4 DISCUSSION

In this study we investigated which drivers and barriers act on the acceptance of meat substitutes. The basic thought was that different levels of acceptance, as expressed by user groups (non-users, light/medium-users and heavy-users of meat substitutes), are under the influence of different factors. We distinguished person-related factors that affect general food choice and product-related factors that are specifically related to meat or meat substitutes.

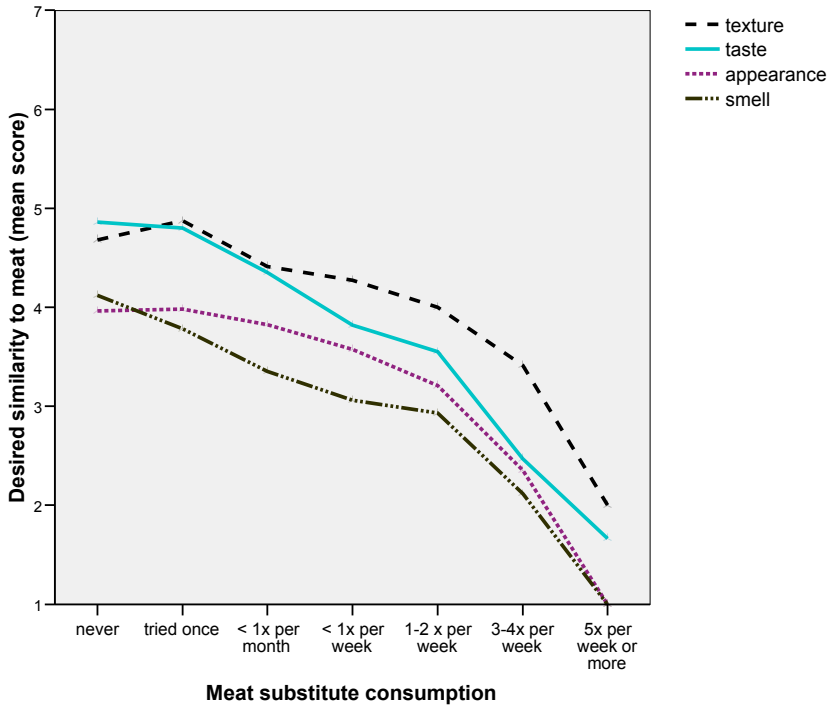

Figure 3b.6: The desired similarity to meat for sensory attributes of new meat substitutes (NL respondents) Mean scores are displayed for the different levels of current meat substitute consumption (X-axis). Items were rated on a 7-point scale with anchors dissimilar-similar to meat.

Table 3b.5: Key factors determining meat substitute acceptance

Type of factor	Factor	Beta-coefficient	*p*-value
Product-related	Familiarity with product	0.37	< 0.001
Person-related	Food Neophobia score	-0.15	0.002
Product-related	Attitudes and beliefs about sensory appeal	0.14	0.015
Person socio-demographics	Country	0.13	0.006
Product-related	Social influence housemate/partner	0.13	0.008
Person socio-demographics	Age	-0.10	0.048
Person socio-demographics	Household size	-0.07	0.014

Y = categories of meat substitute consumption (non-users, light/medium-users, and heavy users). The factors that contributed significantly to the model are listed.

The role of product related factors in acceptance of meat substitutes

The product-related factors, so the particular attitudes and beliefs towards meat substitutes and meat, determined the acceptance of meat substitutes more than general food choice motives. Key barriers for non-users and light/medium-users

seemed to be the unfamiliarity with these products and negative beliefs about the sensory appeal compared to meat.

Meat substitutes were obviously seen as relatively unfamiliar foods. Surprisingly, even for heavy-users of meat substitutes, meat was still more familiar than meat substitutes. After all, meat offers a sense of tradition and familiarity, it still has a central position in Western food culture and is the centre of meals (Barrena & Sánchez, 2009; Douglas & Nicod, 1974; Holm & Møhl, 2000; Meiselman, 2000). How -un-familiarity affects the appreciation of food products was also demonstrated by a study of Raudenbush & Frank (1999). For both neophilics and neophobics they found more positive evaluations of familiar foods compared to unfamiliar foods. Especially neophobics were less willing to try novel foods, even after tasting. The important role of product familiarity on product acceptance can be explained by the fact that consumers generally have a positive bias towards the familiar (Zajonc, 1968). More specifically, Zhou & Nakamato (2007) argued that product familiarity is an important moderator of the incongruency effect because the degree to which an attribute is perceived as incongruent depends on the consumer's familiarity with the product. In case of new food products made by new technologies, like meat substitutes, the perceived risk might also come into play. Consumers will rather prefer a familiar standard, like meat, when there is a high perceived risk (see Ronteltap, Van Trijp, Renes, & Frewer (2007) and Van Trijp & Van Kleef (2008) for extended reviews on consumer responses to newness and new technologies). The unfamiliarity of meat substitutes compared to meat is thus a critical product feature that is limiting consumer acceptance.

Our initial thoughts about the important role of the sensory appeal of meat and meat substitutes were confirmed. It contributed for a large part to the overall quality perception: when one was more positive about the sensory aspects of meat, meat substitutes were used less, and vice versa. The results of our study also confirmed that consumers who do not or rarely use meat substitutes appreciate meat-like sensory properties in a new meat substitute product. Meat's unique taste and texture properties are not reflected in meat substitutes currently on the market (Aiking et al., 2006; McIlveen et al., 1999; Sadler, 2004), which is obviously a substantial barrier for new users, but also relevant to light/medium users. The desired sensory quality of meat is most likely also connected to the familiarity of the specific meat taste and texture. The other way around, heavy-users indicated to appreciate a new meat substitute which is dissimilar to meat. This might be explained by the fact that heavy-users are more experienced users who tend to prefer more unique products (Zhou & Nakamato, 2007). However, it is more likely that it was caused by the specific motives of vegetarians in this user group who do not want to be reminded of meat and usually have developed a strong dislike of the sensory properties of meat (Rozin et al., 1997; Fessler et al., 2003).

Another barrier for both non-users and light/medium-users to use meat substitutes more frequently is related to social influence. These users often had a partner or household member that holds negative attitudes and beliefs towards meat substitutes. Social influence plays an important role in food choice in general, but especially in meal choice. In deciding on what to eat for dinner, one strongly considers the partner's preference (Bisogni et al., 2007; Kemmer, Anderson, & Marshall, 1998), which will also be the case in the choice between meat and meat substitutes. These so called significant others can have strong inhibiting effects on desired dietary changes by displaying emotional responses such as discouragement and scepticism (Paisley, Beanlands, Goldman, Evers, & Chappell, 2008).

Heavy-users were overall more positive about meat substitutes than meat, but not for luxury aspects and satiety by meat substitutes. The perceived difference between meat and meat substitutes for these aspects was even higher by light/medium-users and non-users. Meat, a luxury food by tradition, is regarded as highly suitable for festive occasions and has a certain status (Barrena & Sánchez, 2009; Fiddes, 1991; Grunert, 1997). This clearly does not apply for meat substitutes yet. The lower scores for satiety can probably be explained by a generally lower protein level of meat substitutes. However, it might also been influenced by the image of meat substitutes since non-users have not actually experienced the satiating effect of meat substitutes (Hoek, Luning, Van Boekel, & De Graaf, submitted for publication, Chapter 5).

It seems that in the end the overall personal evaluation of meat substitutes versus meat determines the choice for one of these products, instead of effects by single product-related factors. At the start of the study we assumed that an overall more positive attitude towards meat substitutes than meat acts as a driver to use meat substitutes, and an overall more negative attitude towards meat substitutes acts as a barrier, which was confirmed. Non-users were negative about meat substitutes on most aspects, light/medium-users were more balanced, but still more positive about meat, while heavy-users were distinctively in favour of meat substitutes. Products can be seen as bundles of product attributes with varying capacities for delivering certain benefits and satisfying needs (Kotler et al., 1999). So in the choice between alternative products (i.e. meat or meat substitutes) a trade-off is made which product is able to meet these needs most. This was illustrated by the fact that meat substitutes did receive high scores on the ethical and weight control aspects by non-users and light-users, which is in line with previous image reports (Van Der Lans, 2001; Van Trijp, 1991), but this did not actually contribute to the acceptance of these products. Ethical and weight control aspects were clearly less relevant for these user groups and therefore did not compensate for other negative product-related attitudes and beliefs that were more important to them.

The role of person-related factors in acceptance of meat substitutes

The most important person-related factor that determined meat substitute acceptance is food neophobia. The level of food neophobia differed between user groups: non-users were significantly more food neophobic than light/medium users of meat substitutes, as we initially hypothesized. Food neophobia was obviously an important barrier in acceptance of meat substitutes and especially had its effect on first trials of these products. The results are line with previous reports that food neophobia affects the degree of acceptance of novel or unfamiliar products, both before actually tasting (willingness to try) and after tasting (Arvola, Lähteenmäki, & Tuorila, 1999; Henriques et al., 2009; Pliner, Lähteenmäki, & Tuorila, 1998; Tuorila et al., 1994.) The tendency to avoid and dislike these products are thus presumably also a barrier for repeated use of meat substitutes. The barrier food neophobia might even be more important in the real market place, taken into account the large homogeneity in food neophobia levels of the sample of our study. In fact, 40% of the respondents was positioned in the lower tertile (total food neophobia scores 10-25), which one could consider as a rather food neophilic sample compared to representative samples (Henriques et al., 2009; Pliner & Hobden, 1992, Tuorila et al., 2001).

Surprisingly, food neophobia scores of heavy-users of meat substitutes were comparable to those from non-users. We initially expected that food neophobia scores of heavy-users would be lower, since they were the first consumers who tried the product and continued to use it. One way to explain this is a picky eating style of vegetarians or vegetarian-oriented respondents in the heavy-user group. Tuorila et al. (2001) pointed out that the Food Neophobia Scale has two dimensions namely the -dis-interest in trying new and ethnic foods and a concern vs. carelessness with respect to trying unknown foods. The latter might me particularly applicable to vegetarians. When we excluded vegetarians from food neophobia calculations for the user segments, the average scores of the Dutch heavy-users were comparable to those from light/medium-users. It would therefore be interesting to further test the applicability of the Food Neophobia Scale for consumers with a specific dietary behaviour and orientation, such as vegetarians.

There were some differences in food choice motives between user groups, although these were not main determinants of the acceptance of meat substitutes. Our hypothesis that a higher interest in health, ecological welfare and weight control was a driver for non-users to become light/medium-users was incorrect. For these user groups we initially based our hypotheses on literature about food choice motives of certain types of semi-vegetarianism, including avoidance of different types of meat (Lindeman & Sirelius, 2001; Lindeman & Väänänen, 2000; Pollard et al., 1998; Santos & Booth, 1996). Light/medium-users and semi-vegetarians do display a similar type of dietary behaviour, thus eating less meat, but have a different kind of internal

motivations for doing so (Hoek et al., 2004). Drivers for light/medium-users were more likely a need for variety and interest in new foods. The main differences between light/medium-users and non-users were namely a lower interest in familiarity, sensory appeal (UK) and convenience (NL). Our hypothesis that a higher interest in ecological welfare acts as a driver to become a heavy-user was confirmed. Also other ethical aspects -political values- and a higher interest in the natural content of foods played a role. The vegetarian respondents in the heavy-user group mainly contributed to this due to their high involvement in these topics. Their choice of not eating meat is particularly an expression of a certain ideology (Hoek et al., 2004; Jabs, Devine, & Sobal, 1998; Janda & Trocchia, 2001; Lea & Worsley, 2001, Lindeman & Väänänen, 2000).

Although it was not our primary interest we also found that, besides living in the UK, socio-demographic factors -younger age and smaller households- were related to a higher acceptance of meat substitutes, similar to a previous study (Hoek et al., 2004).

The relation between product- and person-related factors

A strong point of our study is that we used both measures on general personal characteristics (food neophobia and food choice motives) and attitudinal questions specifically related to the products under investigation. Some studies on the acceptance of foods or diets have focussed primarily on personal factors, like food neophobia and general attitudes to foods (e.g. MacNicol, Murray, & Austin 2003; Schickenberg, Van Assema, Brug, & De Vries, 2008) or only on product-related factors (e.g. Heinemann, Behrens & Lanfer-Marquez, 2006; Kubberød, Ueland, Rødbotten, Westad, & Risvik, 2002). It should be noted that using general personality characteristics alone is usually not very effective in explaining specific behaviours, and thus needs a specification towards certain product categories (Van Raaij & Verhallen, 1994; Wansink, Sonka, & Park, 2000). However, consistent with the means-end approach to consumer behaviour, situation-specific food product perceptions can finally be linked to higher abstract values as long as that food product assists in achieving certain personal values (as operationalized by the food-related lifestyle measurement - Brunsø & Grunert, 1998; Grunert, 2006). Similarly, food choice motives can be related to an individual's value system as demonstrated by Lindeman & Sirelius (2001). It is important to be aware of the fact that these links from products to values are only present in an individual when these products, or characteristics, are meaningful to achieve the personally desired values. As described in previous sections, the importance of this link was illustrated by the non-users in our study. They recognized that meat substitutes were more ethical than meat, but this did not make them choose these products, because they lacked a strong ethical value orientation.

Unfortunately, we did not actually analyse how the intermediate relation runs from person-related factors to product-related factors and how this ultimately affects acceptance of meat substitutes. Other researchers have investigated this in more detail from different perspectives, suggesting a partial effect of personal characteristics on food choice by mediation or moderation. This seems to be different across types of food products and related to the involvement in those foods. Chen (2007) did a study on organic foods and reported that food neophobia moderated food choice motives (natural content and political values), and that food neophobia moderated attitudes towards organic foods (but not the intention to purchase organic foods). Eertmans, Victoir, Vansant, & Van den Bergh (2005) discussed how the relation of food choice motives with dietary healthfulness varied with the level of food neophobia. For instance, food neophobia affected the impact of food choice motive weight control on the consumption of some food groups, namely water, light drinks and fruits.

Obviously , person-related factors do have some relation with product-related attitudes and beliefs and ultimate product choice, but it needs further investigation how strong and in what way this exactly affects the choice for meat or meat substitutes.

Further methodological considerations

With respect to the theoretical framework and assumptions of this study, we have seen that these are partially confirmed and need some adjustments. We assumed that there were different drivers and barriers between user groups. This was primarily the case with food neophobia which acts as a barrier for non-users to use meat substitutes. Some food choice motives differed between user groups, especially the importance of familiarity, sensory appeal and ethical aspects. However, product-related attitudes and beliefs were more gradually distributed across the user groups, going from relatively negative scores for most aspects by non-users, to relatively positive scores by heavy-users.

We also assumed that there is a temporal pattern, meaning that the acceptance of meat substitutes occurs over time. Time (including the number of exposures) is probably an important condition to get familiar to these new type of food products. We were not able to actually test and quantify this because we performed a cross-sectional study. However, we did find that heavy-users used meat substitutes already for a longer period of time, sometimes for over 20 years. Other authors have described certain staged processes that occur over time before becoming a vegetarian or vegan (Fox & Ward, 2008; Jabs et al., 1998; Larsson, Rönnlund, Johansson & Dahlgren, 2003; Rozin et al., 1997). However, these type of changes require a certain ideological motivation to deliberately abandon meat from the diet, while non-users and light/medium- users lack this motivation. Combined with the barriers food neophobia,

unfamiliarity, and less sensory attractiveness of meat substitutes, it thus needs more than time alone to increase acceptance by non-users.

For the design of the study and analysis of the data we used key characteristics of the stages of change model and usage segmentation. With respect to the stages of change model, we used only the construct of stages of change for exploration rather than the entire TTM model which includes processes of change, decisional balance, self-efficacy, and temptation. There are a number of criticisms on the stages of change model. An important point is the fact that this model is originally intended for a clinical context. Dietary behaviour is fundamentally different from addictive behaviours such as smoking and drug use (e.g. Horwath, 1999; Kristal et al., 1999; Povey, Conner, Sparks, James, & Shepherd, 1999; Spencer et al., 2007). Another point of discussion is the basis on which respondents are assigned to certain stages, which is mostly done by self-reported consumption data. This suffers from a mismatch between perceived and actual dietary behaviour (e.g. Horwath, 1999; Povey et al., 1999). Valid and reliable staging algorithms are currently only available for fruit and vegetable consumption and dietary fat intake (Spencer et al., 2007), and not for products like meat and meat substitutes. Furthermore, Weinstein, Sutton, & Rothman (1998) warn for using 'pseudo' stages, so the use of stages for processes that are in fact continuous. The issues raised here are also major points of attention in the interpretation of our study.

To our knowledge, there are no studies that have used the stages of change construct for the acceptance of meat substitute products. The closest related study is from Lea et al. (2006) who examined consumers' readiness to change to a plant-based diet. However, they used the stages of change model to segment the population with respect to the consumption of a plant-based diet instead of certain products. They commented that the concept 'a plant-based diet' was unknown to respondents, which is in line with comments on stages algorithms that do not allow for the fact that consumers eat products instead of nutrients or diet types (Spencer et al., 2007). Only a few studies actually focused on consumption of specific products, like milk (Gulliver & Horwath, 2001; Gulliver & Horwath, 2001) while most stages of change research is on broader product categories, like fruit and vegetables (Spencer et al., 2007). It needs further research whether the stages of change model is applicable for non-health related behaviour, such as environmental issues. Based on the experiences with this study, we propose that issues involving long-term benefits for the environment probably involve different psychological processes than health issues that are beneficial for the person himself. For now, the basic thought that consumers are different according to their levels of acceptance can be described more straightforward by usage segmentation.

Usage segmentation is only based on a behavioural outcome measure, which is generally seen as a shortcoming because it is often difficult to explain reasons behind the usage behaviour (Weinstein, 2004). Therefore we combined the usage data with

product-related attitudes and beliefs and personal characteristics in our study. Other segmentation approaches might have given more distinction and insight, which is recommended for future research on this topic. Wansink, Sonka, & Park (2004) suggested to use the so called seeker avoider segmentation which differentiates between those who are neutral to the product and those who actively seek it out. This might be more relevant than usage segmentation in cases when the product category is not purchased frequently and when there is a strong attitude towards the product category, as it is the case with meat substitutes. Another interesting option is the use-diffusion model for acceptance of innovative products. This model combines two constructs, namely variety of use and rate of use, involving the time a person spends using the product during a certain period (Shih & Venkatesh, 2004).

With respect to the set up of the survey, a strong point is that we have not considered meat substitutes in isolation but put it against its main reference, namely meat. We actually found that meat substitutes did substitute meat, which is relevant for the overall research aim to find sustainable alternatives to decrease meat substitutes. Product-related attitudes and beliefs towards meat substitutes were directly expressed in relation to meat by calculating relative scores (see also Nasser El Dine & Olabi, 2009). However, we based the outcome measure product acceptance only based on the consumption of meat substitutes. For studies on new food products that substitute existing products, it is of interest to explore other ways to express product acceptance. The degree of acceptance could for instance be expressed by the actual degree of substitution, involving both the frequency of consumption of the reference food (meat) and the new food (meat substitutes).

A point of attention is that we did not asses the perceived degree of newness of actual meat substitute products by consumers. This would greatly have helped in the interpretation of the results, given the role of product familiarity and food neophobia in acceptance of meat substitutes. The same holds for the perceived risk in relation to meat substitutes and meat. In addition, questions were asked about the entire meat substitute category, which obviously constitutes from a range of different products that vary in sensory properties and overall similarity to meat.

Conclusions and implications for new meat substitutes

This study showed that the key barriers for current non-users of meat substitutes were the relatively unfamiliarity and low sensory appeal of these products compared to meat. In addition, non-users of meat substitutes also had a higher tendency to avoid new foods (food neophobia). Both non-users and light/medium-users had overall far more positive attitudes and beliefs towards meat, so in the choice between alternatives the scale will tip towards meat instead of meat substitutes. Although non-users and light/medium-users gave high scores for ethical and weight control aspects

of meat substitutes, this obviously did not influence their product choice towards meat substitutes because these aspects were less relevant to them.

It does seem that there are growth opportunities for the market of meat substitutes, which is anyhow the case for the Netherlands. The U.K. can be seen as a forerunner in the acceptance of these new type of food products. Dutch consumers might follow over time since Dutch non-users and light/medium-users indicated to intent to use meat substitutes in the future. In order to achieve this, current perceived barriers need to be lowered and drivers enforced. Essentially this means that establishing a good fit of the product with the behaviour, perception, and needs of non-users and light/medium-users, which is clearly different from current heavy-users of meat substitutes.

Personal characteristics of consumers, such as food neophobia and food choice motives, are very difficult to transform. However, what can be done is to take these personal characteristics seriously into consideration in the development and positioning of new meat substitutes. With respect to food neophobia, Tuorila et al. (1994) reported that providing certain verbal information, e.g. about product use, enabling resemblance to more familiar foods, and bringing about product exposure, reduced the initially negative neophobic response. With respect to internal motivations and how this affects the daily choice of foods, this study shows that current non-users and light/medium-users of meat substitutes are not focusing on ethical aspects, in contrast with heavy-users and vegetarians. Although non-users and light/medium-users do acknowledge the ethical aspects in meat substitutes, it is not something they are aiming for in a food product. So what can be done is to focus on the product attributes that do fit with their orientation on familiarity and sensory attractiveness in foods. Corresponding to earlier remarks of Sadler (2004), McIlveen et al. (1999), and Kuntz (1995), we confirm that future growth opportunities exist for products that are more similar to meat and that overall sensory quality needs further improvement. A meat-like product could also help in overcoming unfamiliarity and uncertainty regarding new meat substitutes. Other improvement areas, which also apply for current heavy-users, are the satiating properties and a more luxury product image. In order to develop new sustainable meat substitutes that substantially replace meat on the plate, more research is needed on the identification and technological realization of the desirable meat-like properties, and the effect of repeated exposure on consumer acceptance.

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Chapter 4

Identification of new food alternatives: how do consumers categorize meat and meat substitutes?

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ABSTRACT

New meat substitutes need to be recognized as alternatives to meat. We therefore investigated how non-vegetarian consumers perceived and categorized these products. Thirty-four participants performed a free sorting task with 17 meat products, 19 commercially available meat substitutes, and 4 new concepts (not meat-like), followed by similarity and typicality ratings. Results indicated that categorization was largely influenced by the taxonomic classification of meat, so by categories 'pork', 'beef' etc. Meat substitutes were grouped separately from non-processed meat products. However, generated categories like 'pieces' and 'sausages' contained both meat substitutes and processed meat products, and were perceived as very similar. In contrast, new concepts were regarded as a completely different food category such as 'appetizers'. Meat substitutes need to have a certain resemblance to meat in order to replace meat on the plate. This can be achieved by a similarity in appearance or by referring to shared scripts/goals, such as a similar application in meals.

4.1 INTRODUCTION

The need for alternative food products

Having meat for dinner is nowadays under debate and is referred to as an environmentally unfriendly food choice due to an inefficient use of land and energy, and emission of gases by meat production (McMichael, Powles, Butler, & Uauy, 2007; Pimentel & Pimentel, 2003; Tilman, Cassman, Matson, Naylor, & Polasky, 2002). Policy makers and organisations involved with sustainable consumption and production are hoping to see consumers making a shift to a more sustainable product (e.g. Aiking, De Boer, & Vereijken, 2006; Swedish National Food Administration, 2009; United Nations, 2007). There are certain alternative products for meat on the market, so called meat substitutes or meat replacers, but market shares of these products are still very low, estimated around only 1-2% of meat (e.g. Anonymous, 2004). Current meat substitutes are obviously not a real alternative for non-vegetarian consumers.

An explanation for the lack of a success of meat substitutes is, amongst other things, a lower sensory quality (Elzerman, 2006; Hoek et al., submitted for publication, Chapter 3b; McIlveen Abraham, & Armstrong, 1999; Sadler, 2004) due to current technological constraints to mimic a meat-like taste and texture. An option is to develop radically new meat substitutes, so called Novel Protein Foods, which are not necessarily meat-like (Aiking et al., 2006; Jongen & Meerdink, 2001). However, this approach is accompanied by other issues: Can a product that is totally different from meat, replace meat on the plate? Will people recognize Novel Protein Foods as an alternative to meat? It is therefore important to make sure that new alternative products for meat are recognized as such.

How consumers identify an alternative product

How consumers perceive a certain product does not depend only on that particular product, but also on how the product relates to other products (e.g. Antonides & Van Raaij, 1998, Berlyne, 1960; Carpenter & Nakamoto, 1989; Shocker, Bayus, & Kim, 2004). A possible alternative product is *compared* to other products on certain characteristics: is it more similar or dissimilar to a reference product? (Dhar & Glazer, 1996; Medin, Goldstone, & Markman,1995). Consequently, *a set* of product alternatives is formed based on shared characteristics. Consumers usually choose the preferred option from alternatives from the same product category (Antonides & Van Raaij, 1998; Lynch, Marmorstein, & Weigold, 1988; Nedungadi, 1990). It is therefore relevant for development of new product alternatives, such as meat substitutes, to understand how consumers classify products in categories (as reviewed by Felcher, Malaviya, & McGill, 2001; Van Trijp & Van Kleef, 2008). This involves the process of categorization.

Background on categorization

Categorization implies that consumers group products into certain categories. A category is defined as a set of similar objects that have one or more characteristics or functions in common. So there are different ways to form a category: i.e. objects can be grouped based on similar attributes or because they lead to similar outcomes (Antonides & Van Raaij, 1998; Felcher et al., 2001). When a category is formed based on similar attributes, the objects or products within this category share certain physical characteristics that are relevant to consumers, for example a category of red fruits (based on similarity in colour) or round cookies (based on similarity in shape). Within this type of categorization there are so called taxonomic categories which is a hierarchical system based on naturally occurring relationships, such as bananas and strawberries are both fruits (Rosch & Mervis, 1975; Rosch & Loyd, 1978). The shared features on which taxonomic categories are based do not necessarily have to be clearly visible, and can be based on an agreed classification (scientific or professionally based) and learned by consumers to organize information about alternatives (e.g. Johnson & Mervis, 1997; Sujan & Dekleva, 1987). For instance, a taxonomic category such as 'vegetables' represents foods that share their origin and nutritive content, while this is not obvious from the outside (Nguyen & Murphy, 2003).

Besides categorization on similar attributes, products can also be placed in one category because they lead to similar results or outcomes. These types of categories are called goal-derived categories; e.g. chewing gum and toothpaste both have the outcome of a fresh breath. Although members of goal-derived categories can have some physical attributes in common (e.g. a mint flavour), these categories are primarily created with respect to the fulfilment of certain goals (e.g. Barsalou, 1983, Ratneshwar, Barsalou, Pechmann, & Moore, 2001). Another type of categorization for which similar physical attributes are of less importance is the use of script categories. These categories include products that play the same role in a routine or event, such as products used for breakfast time or at a birthday party (e.g. Nelson & Nelson, 1990; Mandler, Fivush, & Reznick, 1987).

What constitutes a category is not very strict; category membership is more a matter of degree. This is called 'the family resemblance' approach (Rosch & Mervis, 1975; Rosch & Loyd, 1978). Some products are better examples of a category than are others, for example a chair is a more typical example of furniture than a bookcase. Categories thus have a graded structure, with the most representative members in the centre and weaker members on the outside (Barsalou, 1985; Viswanathan & Childers, 1999). In the centre of a category is the prototype. This is a kind of ideal that consumers have in mind based on previous experiences. It combines the most important properties of a category but *does not have* to exist in the real world (Antonides & Van Raaij, 1998; Rosch & Lloyd, 1978). An exemplar or specimen is a concrete product or item

which is a typical example for a category, which does actually exist (Antonides & Van Raaij, 1998; Medin, Altom, & Murphy, 1984). The prototype theory and the exemplar model complement each other, and both stress the importance of similarity between products in categorization.

Categorization of foods

How food products are categorized probably differs from categorization of other types of products. Food seems to be the only domain that has both taxonomic and script-based categories. As a consequence food products are sometimes cross-classified into many categories (Nguyen & Murphy, 2003; Ross & Murphy, 1999). For example, foods are related to other foods because they are in the same script-based category (e.g. eggs and toast are both breakfast foods) and/or by shared properties (e.g. toast and muffins are both made from wheat) (Ross & Murphy, 1999). The category meat is such an example of a strong taxonomic category, which is of relevance for meat substitutes.

Since new sustainable meat substitutes should be replacers for meat in the diet, the first step is to find out how consumers perceive and categorise these types of products. We were interested whether meat and meat substitute products are seen as completely separate categories or whether shared categories exist and if so, on what basis these categories are formed. This information is valuable for product design and marketing of Novel Protein Foods. After all, when meat substitutes share a certain category with meat it will be more likely they will be chosen as an alternative. The objective of this work was therefore to examine which category representations consumers have about meat, commercially available meat substitutes, and new concepts of Novel Protein Foods.

4.2 METHODS

In order to get insight in how consumers actually categorize meat and meat substitute products, we did a study in which participants categorized these products by a free sorting task (Step 1) and subsequently rated the degree of similarity between a selection of products and how typical the products were for the generated categories (Step 2).

Participants

The intended target population of Novel Protein Foods are current meat-eaters, therefore we recruited 34 *non*-vegetarian consumers for this study (Table 4.1). The frequency of use of meat substitutes by the participants ranged from: 'never used' to 'a few times per week'. In the study enrolment questionnaire, meat substitutes

were defined as: 'protein-containing foods that are primarily vegetable-based and that replace the function of meat as a meal component used for hot meals. Examples include vegetarian schnitzels, burgers, tofu, tempeh, and stir-fry products. These products can also be meal components in ready-made meals. It does not include fish, eggs, cheese, nuts or legumes.' Participants received a voucher of 10 euro for completion of the whole study.

Table 4.1: Study population characteristics (n=34)

Gender	Females	66%
Age (years)	Mean (range)	38 (19-69)
Education level	Low	21%
	Medium	30%
	High	50%
Meat consumption	Less than 1x per week	6%
	1-2x per week	6%
	3-4x per week	29%
	5x per week or more	59%
Consumption meat substitutes	Never	24%
	Tried a few times	27%
	Less than 1x per week	33%
	1-2x per week	12%
	3x per week or more	6%

Products

Selection of products currently on the market — We were interested in how consumers categorize meat and meat substitute products that are currently commercially available. The aim was to include a wide range of products varying in relevant product features. As a preparation for the selection of products, we did a market inventory, in-depth interviews (n = 15) and a survey (n = 63) in which we explored which product features consumers in general pay attention to when identifying substitute products. The final selection of commercially available products (17 meat products and 19 meat substitute products) therefore varied in product form (e.g. pieces, sausage, whole piece meat), product colour (e.g. white, brown) and main ingredient (e.g. chicken, soy, beef) (Table 4.2). Vegetarian varieties of meat products (e.g. hamburger and vegetarian hamburger, mince and vegetarian mince) were chosen when these were commercially available. Prior to the study, the types and number of products were checked in a test with 8 participants.

Selection of Novel Protein Foods concepts — Besides the currently commercially available meat substitute products, we were particularly interested in how consumers

would subsequently categorize Novel Protein Foods that are radically different in appearance from meat. Therefore four new concepts of Novel Protein Foods, like luxury products from a caterer, that were mainly based on vegetables combined with a protein source, were included in the study as well (Table 4.2).

Product display — The 40 products were photographed under standard conditions against a white background from which picture cards (10 x 13,5 cm) were made. The products were shown uncooked, as is usually the case in a store. To avoid strong effects by brands or packaging design, the products were shown without packaging but with an information label that described the main ingredient (such as 'chicken' or 'soy', Table 4.2).

Table 4.2: Overview of the products used in the study

Commercially available products				New concepts	
17 Meat products		19 Meat substitute products		4 Novel Protein Foods	
Product	*Label*	*Product*	*Label*	*Product*	*Label*
Steak	Beef	Vegetable burger	Soy/vegetables	Filled tomato with cheese	Vegetable/cheese
Cutlet	Pork	Vegetable balls	Vegetables/soy/ wheat	Filled sweet pepper with nuts	Vegetable/nuts/ rice
Chicken drumsticks	Chicken	Lentil sticks	Lentils/soy	Mushroom pie	Vegetable/ mushroom
Chicken fillet	Chicken	Quorn fillet	Fungi	Pesto cups with egg, cream, tomato	Wheat/egg
Chicken pieces	Chicken	Quorn pieces	Fungi		
Schnitzel	Pork	Vegetarian schnitzel	Soy		
Hamburger	Beef	Vegerian burger	Soy		
Cordon bleu	Pork	Vegetarian Cordon bleu	Soy		
Satay burger	Pork	Javanese burger	Soy		
Chicken burger	Chicken	Falafel burger	Pea/soy		
Sausage	Pork/ beef	Vegetarian sausage	Wheat/soy		
Smoked sausage	Pork	Vegetarian smoked sausage	Wheat/soy		
Bacon slivers	Pork	Tofu slivers	Soy		
Nasi/bami goreng meat	Pork	Nasi/bami goreng pieces	Fungi		
Satay	Pork	Vegetarian satay	Vegetables		
Mini minced beef balls	Beef	Vegetarian balls	Soy		
Minced beef	Beef	Vegetarian mince	Soy		
		Tofu pieces	Soy		
		Vegetarian nuggets	Soy		

Procedure

The study protocol consisted of 2 parts for each participant: a free sorting task (Step 1) and a questionnaire (Step 2). Between Step 1 and Step 2, there was at least one week time.

Step 1 — The first step involved the generation of categories focussing on the following questions: Which products, both meat and meat substitutes, are placed together in groups? What types of labels are used to describe the formed groups? This was done by a free sorting task, which is a procedure in which participants group stimuli (e.g. products or picture cards) based on their perceived similarities. The method assumes that how the stimuli are sorted into categories represents the consumer's underlying mental processes how products are perceived and which associations people have with these products [see literature on this technique reviewed by Blake, Bisogni, Sobal, Devine & Jastran (2007)]. The free sorting task was performed by each participant individually, and took on average 45 minutes. The participants first received a pile of 36 cards with the commercial products, which were sorted at random. They were instructed to sort the cards into piles of similar products and that they were free to form as many groups as they wanted, but more than 1 and less than 36, to ensure grouping. After grouping of the cards, the participants were asked to give each formed group a description name using their own words, and on what basis each of the groups were formed. Each time, the reason behind the grouping and what was typical or characteristic of each group was discussed. When the sorting task with the 36 commercial products cards was completed, the participant received the 4 cards with the Novel Protein Foods concepts. We decided to introduce these cards after the categorization of the existing products because this would be more in line with the future situation. After all, when new products such as Novel Protein Foods are going to be launched on the market, consumers already have certain knowledge based on existing products. Participants were free to add the cards with Novel Protein Foods to previously formed groups, or to make new groups with all 40 cards.

Step 2 — In Step 2 we wanted to investigate the validity and structure of the individually generated categories from Step 1, see procedure used by Ross & Murphy (1999): Which products are considered to be typical for the generated categories category (*typicality*)? And which products are considered to be more similar to each other (*similarity*)? Participants therefore filled out a questionnaire that consisted of typicality and similarity ratings. The product pictures from the sorting task were included in the questionnaire. Typicality ratings are alternative measures of category membership (Saunders, 1991) and give an indication of how typical, or representative, a product is for a generated category, so the distance of a product to the prototype of that category. In this part of the questionnaire, all the 36 commercial meat and meat substitute products were rated for their typicality of 18 generated categories. We decided to exclude the new concepts of Novel Protein Foods, since these were not

categorized with the other products (as described in the Results section). The following question was used (see procedure Rosch & Loyd, 1978): 'Please indicate how typical you feel this product is for the category *sausage*' (*example*). Each product was rated on a seven-point Likert scale, with the endpoints "not typical at all" to "very typical".

Similarity ratings give an indication to which degree respondents perceive products to be similar, so the distance between 2 products. Because it was impossible to have participants rate all 630 combinations of products - (36 x 35) / 2 -, we had to make a selection of the most relevant product set based on the outcomes of Step 1. First, we selected the products that were grouped together in the free sorting task. All products that were grouped together by at least 7 participants were included in the selection (7 was the median of all product co-occurrences). For each category, product pairs were formed with the product that occurred most frequently within that category, which we called 'the exemplar'. When there were 2 exemplars (products that both occurred with the same frequency in the generated category), product sets were made to compare to both these 2 products. Second, product combinations were made of meat products that had a vegetarian variety: e.g. Cordon Bleu vs. Vegetarian Cordon Bleu. The similarity ratings in the questionnaire consisted in total of 80 product pairs that were rated on a seven-point Likert scale, with anchors "very dissimilar" to "very similar".

Data analysis

Step 1 — A category was listed when a group name was mentioned by 2 participants or more. Individual descriptions of categories that were quite similar were seen as one category (e.g. 'parts', 'cubes', and 'pieces' were called the category 'pieces'). For a product to be a member of a category, it had to be mentioned by more than 50% of the participants. Co-occurrence of the products were considered for each individual participant by formation of a matrix (product x product) in which '1' indicated that products co-occurred in a similar group and '0' no co-occurrence. An overall co-occurrence matrix was calculated by summing the 34 individual matrices. High numbers indicate high co-occurrence and thus a higher similarity between samples. A hierarchical cluster analysis was performed with the co-occurrence matrix (method: between-group linkage and chi-square measure) to generate a clusterdendogram.

Step 2 — The mean typicality score was calculated of every product-category combination. Differences between products within the generated categories were tested by ANOVA. Similarly, the mean similarity score was calculated of the 80 product-product combinations. ANOVA was used to test the differences between similarity scores within categories. Data-analyses were performed with SPSS 14.0 and *p*-values below 0.05 were considered statistically significant.

4.3 RESULTS

Generated categories of meat and meat substitutes

Eighteen different categories were generated by the free sorting task (Table 4.3). The categories named 'pieces', 'sausages' and 'chicken' were most common. The table shows that categories were primarily formed on the basis of both *ingredient type* (e.g. chicken) and *product form* (e.g. pieces). This was not only on participant group level, individuals also applied these two ways of categorization simultaneously.

Categories based on *product form* or appearance were: 'pieces', 'sausages', 'burgers', 'coated', 'balls', 'minced meat', 'satay' and 'snacks'. Participants also referred to a certain usage or application of the products, for example 'small pieces and mince to be used in a sauce'. Note that participants did not group meat and meat substitutes separately. There were in fact combined categories in which both meat substitutes and meat products occurred. This occurred more frequently with processed products, such as 'burgers', 'sausages', 'coated products', and 'mince' (Table 4.3). A typical comment was: 'Because of the outside of the product, coated with a crumbed layer, they look more similar'.

However, when categorization was based on *ingredient*, meat products were put separately. This occurred especially with *whole piece* meat products. Categorization by means of ingredient type then matched the animal source, for example 'chicken', 'pork', and 'beef'. Participants explained: 'This is very characteristic for meat', 'You can see they have done nothing with it, it just came right of the animal', 'There is not a single meat substitute that has this kind of appearance'. For chicken pieces, the ingredient type (chicken) is obviously dominant over product form, since chicken pieces were not once added to the category pieces: 'It is meat which is only cut into pieces'.

Other types of categories that were formed less frequently were: 'easy', 'I would not buy', 'snacks' and '3-components meal'. The Dutch traditional 3-components meal category constituted *only* of meat products. There was also a category called 'legumes' generated from meat substitute products that had noticeably pieces of vegetables in them.

The overall clusterdendogram illustrates the hierarchy in products in more detail (Figure 4.1). The products were roughly divided in meats (upper part of the figure) and processed products (lower part). The animal source was the primary base for categorization ('pork', 'beef', 'chicken') with meats. In contrast, the processed products are first categorized based on form (e.g. 'burgers') and secondly on ingredient type (vegetarian versus meat, and then type of vegetarian ingredient – soy or fungi). The vegetarian variants of sausages were obviously regarded as closest to meat as they were closely linked to the meat groups. Note that 'mince' and 'chicken pieces' were grouped in the meat categories, while more processed and coated meat products such as 'chicken burger' and 'schnitzel' were grouped in the burger categories.

Table 4.3: Categories generated by the free sorting task with meat and meat substitutes

Category*	n participants	Type of products**	Products in the category**
Pieces	34	Meat substitutes	Tofu slivers (V), Tofu pieces (V), Quorn pieces (V), Nasi/bami goring pieces (V)
Sausages	26	Meat Meat substitutes	Smoked sausage, Sausage, Vegetarian sausage (V), Vegetarian smoked sausage (V)
Chicken	20	Meat	Chicken fillet, Chicken drumsticks, Chicken pieces
Burgers	18	Meat Meat substitutes	Vegetarian burger (V), Vegetable burger (V), Falafel burger (V), Chicken burger
Meat	18	Meat	Steak, Cutlet, Chicken fillet, Chicken drumsticks
Meat substitutes	17	Meat substitutes	Tofu pieces (V), Tofu slivers (V), Vegetarian mince (V), Vegetarian cordon bleu (V)
Coated (with crumbs)	16	Meat Meat substitutes	Cordon bleu, Schnitzel, Javanese burger (V) Vegetarian schnitzel (V), Quorn fillet (V), Satay burger, Vegetarian cordon bleu (V), Vegetarian burger (V)
Balls	13	Meat Meat substitutes	Vegetarian balls (V), Vegetable balls (V), Mini minced beef balls
Minced meat	12	Meat Meat substitutes	Minced beef, Vegetarian mince (V)
Pork	12	Meat	Bacon slivers, Nasi/bami goreng meat, Cutlet, Satay, Cordon bleu, Chicken pieces, Schnitzel, Satay burger
Fungi	11	Meat substitutes	Quorn pieces (V), Nasi/bami goreng pieces (V), Quorn fillet (V)
Satay	11	Meat Meat substitutes	Satay, Vegetarian satay (V)
Beef	10	Meat	Hamburger, Steak, Minced beef, Mini minced beef balls
Snacks***	5	Meat substitutes	Vegetable balls (V), Vegetarian balls (V), Vegetarian nuggets
3-components meal***	5	Meat	Cutlet, Hamburger, Steak
Legumes***	3	Meat substitutes	Lentil sticks (V), Falafel burger (V)
Easy***	3	Meat	Products varied
I would not buy***	3	Meat Meat substitutes	Products varied

*Generated categories are based on groups made by more than 2 participants.
**Products that were mentioned by at least 50% of the participants that formed that specific category in descending order of occurrence.
***Content of the categories varied, table indicates the products that were mentioned by the majority.
(V) indicates a meat substitute product.

The new concepts of Novel Protein Foods, largely based on vegetables in appearance, were obviously seen as a distinct category since these were grouped separately from the 36 commercial available meat and meat substitute products by most of the participants (n = 25). The reason for this became clear by discussing the motivation for the formation of the groups. Some typical comments were: 'You cannot use it as meat, and you cannot blend it into a dish', 'You can serve this as luxury vegetables', 'I put these products with the group mince, because you can put mince in the cups', 'This

is something you cannot eat every day, like you can with meat'. It was often mentioned that the concepts of Novel Protein Foods were not seen as substitutes for meat, but were thought to be an appetizer or side-dish. Participants (n = 9) who grouped the new products in combination with a previous group commented that they thought it would taste good *in combination with meat*.

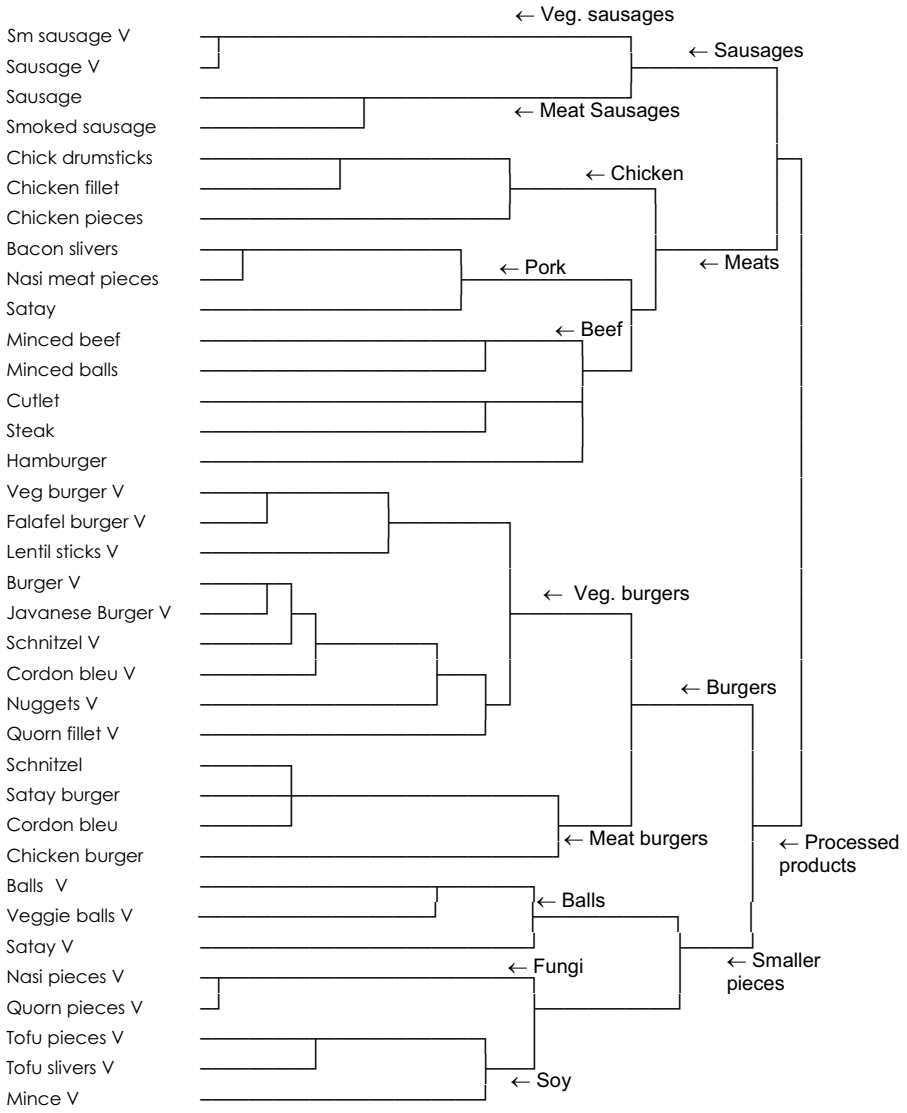

Figure 4.1 Clusterdendogram of meat and meat substitutes
Hierarchy of 17 meat products and 19 commercially available meat substitute products obtained by a free sorting task. Reading from right to left, the main divisions and further branches are revealed. The figure shows that in case of meat (mainly upper part figure), the classification by animal source is more dominant, while with processed products (mainly lower part figure), the product form is more dominant and contains both meat and meat substitutes.

Typical products for categories

The results of the typicality ratings have to be interpreted as a measure for the degree to which a product is perceived to be representative of a category (Loken & Ward, 1990). The outcomes of the typicality ratings (Table 4.4) were in line with the outcomes of the free sorting task: products that were more typical of a category also occurred more frequently in that category during the free-sorting task, for example the most typical product for 'chicken' was 'chicken drumsticks'. There was a large variation in typicality scores; from a low mean typicality score of 1.2 for product 'vegetarian mince' for category 'chicken' to high typicality scores like 6.7 for product 'vegetable balls' for the category 'balls' (Table 4.4). Within each category there were significant differences between typicality scores of products. Most categories had several products that were in the same range of typicality (Table 4.4). Products that were very typical items in the meat categories ('meat', 'beef', 'chicken') were whole pieces of meat. The most typical product for the generated category meat substitutes was 'tofu slivers'. However, there were also a number of categories that had both meat and meat substitutes as typical representative products: 'vegetarian balls' were even seen as the most typical product for the category 'balls'. Other categories in which both meat and meat substitutes scored high on typicality were: 'burgers', 'coated', 'minced meat', 'pieces', 'satay', and 'sausages'. Thus, a meat substitute could be a typical product of a category with meat, but this only occurred with categories that reflected processed products.

Table 4.4: Typical products and their typicality scores for the generated categories

Category	'Exemplar' - most typical product	mean	2nd typical product	mean	3rd typical product	mean
Balls	Vegetable balls (V)	6.7	Mini minced beef balls	6.3	Vegetarian balls (V)	6.3
Beef	Steak	6.3	Mini minced beef balls	5.7	Hamburger	5.7
Burgers	Chicken burger	6.4	Satay burger	6.3	Vegetarian burger (V)	6.3
Chicken	Chicken drumsticks	6.7	Chicken pieces	6.6	Chicken fillet	6.5
Coated	Vegetarian schnitzel (V)	6.4	Satay burger	6.2	Vegetarian cordon bleu (V)	6.2
Fungi	Quorn pieces (V)	5.8	Nasi/bami goreng pieces (V)	5.5	Quorn fillet (V)	5.1
Legumes	Lentil sticks (V)	5.3	Falafel burger (V)	4.3	Vegetable burger (V)	3.4
Meat	Cutlet	6.2	Steak	6.1	Nasi/bami goreng meat	6.1
Meat replacers	Tofu slivers (V)	6.4	Tofu pieces (V)	6.2	Vegetable balls (V)	6.0
Minced meat	Minced beef	6.7	Mini minced beef balls	6.0	Vegetarian mince (V)	5.4
Pieces	Veg. nasi/bami goreng pieces (V)	6.6	Tofu slivers (V)	6.5	Quorn pieces (V)	6.5
Pork	Bacon slivers	6.4	Cutlet	6.4	Nasi/bami goreng meat	5.8
Satay	Satay	6.6	Vegetarian satay (V)	5.7	Satay burger	3.4
Sausages	Sausage	6.7	Smoked sausage	6.7	Vegetarian smoked sausage (V)	6.2
Easy	Smoked sausage	5.9	Chicken burger	5.8	Vegetable burger (V)	5.8

Category	'Exemplar' - most typical product	mean	2nd typical product	mean	3rd typical product	mean
I would not buy	Vegetarian sausage (V)	5.1	Vegetarian smoked sausage (V)	5.0	Lentil sticks (V)	4.7
Snacks	Vegetarian balls (V)	5.2	Mini minced beef balls	5.2	Vegetable balls (V)	4.9
3-components meal	Vegetarian vegetable balls (V)	5.2	Schnitzel	5.1	Sausage	5.1

Thirty-four participants rated typicality on a 7-point Likert scale of each of the products (product name, ingredient label and picture of unpackaged product) for the 18 generated categories.
Products were meat and meat substitutes.
(V) indicates a meat substitute product.

Similarity between products

During the sorting task, some products were grouped together very frequently. For example, the products in the sausage category were placed together very often; the 'vegetarian smoked sausage' and 'vegetarian sausage' were put in the same category by all 34 subjects and the meat sausages ('smoked sausage' and 'sausage') co-occurred 31 times (Appendix 4.A). This means that across individual participants, these categories consisted mostly of the same products and obviously these products were perceived to be very similar. For other categories, such as 'burgers', 'coated', 'meat', 'meat substitutes' and 'pieces', the co-occurrence of the products was lower. This means that although the type of category is made very often, the products that were put in this category varied more across participants.

Similarity between products ranged from 2.0 to 5.6, and except for the category 'meat', these scores were significantly different between product pairs within all categories. The similarity ratings supported the results of the free sorting task (Table 4.5). Products that were perceived to be very similar were mainly processed products from the categories based on product form: 'sausages', 'balls' and 'burgers'. Table 4.5 illustrates that there were pairs of meat substitute products and meat products that were perceived to be very similar: 'smoked sausage' & 'vegetarian smoked sausage', 'cordon bleu' & 'vegetarian cordon bleu', and 'minced beef' & 'vegetarian mince'. Vegetarian equivalents of relatively unprocessed meat products, like 'Quorn fillet' and 'chicken fillet', were rated low for similarity.

4.4 DISCUSSION AND CONCLUSION

We investigated which category representations people have about meat and meat substitutes as a first step to guide product development of new sustainable meat substitutes, so called Novel Protein Foods. The presupposition is that there is a higher chance that a meat substitute will be chosen as an alternative when this product

Table 4.5: Similarity of the selected meat and meat substitute products

Category	Product pair	Meat - Veg*	Mean similarity	Co-occurrence
Sausage	Smoked sausage & Sausage		5.6	31
	Smoked sausage & Vegetarian smoked sausage (V)	MV	5.3	21
	Sausage & Vegetarian sausage (V)	MV	4.9	19
Balls	Vegetarian balls (V) & Vegetable balls (V)		5.5	23
	Vegetarian balls (V) & Mini minced beef balls	MV	4.7	15
Burger	Vegetarian burger (V) & Vegetable burger (V)		5.4	19
	Vegetarian burger (V) & Javanese burger (V)		5.3	29
	Vegetarian burger (V) & Falafel burger (V)		5.2	19
	Vegetarian burger & Hamburger	MV	4.3	7
Coated	Cordon bleu & Schnitzel		5.0	28
	Cordon bleu & Vegetarian cordon bleu (V)	MV	5.1	12
Meat replacer	Tofu pieces (V) & Tofu slivers (V)		5.0	27
Chicken	Chicken fillet & Chicken pieces		5.0	23
	Chicken pieces & Quorn pieces (V)	MV	3.7	7
	Chicken fillet & Quorn fillet (V)	MV	3.2	1
Pieces	Tofu slivers (V) & Vegetarian nasi/bami goreng pieces (V)		4.9	17
Minced meat	Minced beef & Mini minced beef balls		4.9	18
	Minced beef & Vegetarian mince (V)	MV	4.7	12
Fungi	Vegetarian nasi/bami goreng cubes (V) & Quorn fillet (V)		4.7	13
Satay	Satay & Vegetarian satay (V)	MV	4.6	15
Beef	Hamburger & Vegetarian burger (V)	MV	4.5	12
Pork	Nasi/bami goreng meat & Satay		4.4	19
Meat	Steak & Cutlet		3.2	20

*Indicates Meat-Vegetarian equivalents.
Thirty-four participants rated similarity between products (by given product name, ingredient label and picture of unpackaged product) on a 7-point Likert scale of 80 product pairs.
The table displays only product pairs that had the highest similarity score within a category, product pairs that had a similarity rating ≥5.0, and product pairs that were meat-vegetarian equivalents (like satay & vegetarian satay).
Co-occurrence indicates the number of times these products occurred together in a group in the free-sorting task.

is grouped with meat in certain categories. Before the study it was unclear how consumers would categorize meat and meat substitutes and on what basis.

The results indicate that the perception of a set of meat and meat substitute products was largely influenced by a taxonomic classification of meat, thus based on the animal source, like 'pork', 'beef' or 'chicken'. Meat substitutes were not grouped with meat with those types of categories. However, there were also cases in which both meat and meat substitutes were combined in one category, such as the categories 'burgers' or 'sausages'. These categories constituted typically of *processed* products, e.g. the category 'burgers' contained both 'hamburgers' and 'vegetarian burgers'. Within these types of categories, the product form (e.g. burger) dominated the ingredient (either a soy or pork burger). Meat substitutes can even be considered as very typical, and

thus representative, for the categories 'burgers', 'meat balls', 'coated', and 'sausages'. Meat and meat substitute products within these categories were considered to be highly similar. New concepts of Novel Protein Foods that were radically different in appearance from meat did not group with the meat products. These new concepts were obviously seen as a total different category of products, rather as a side-dish or aperitif instead of a substitute for meat.

The strong taxonomic categorization of meat products

We are not aware of previous publications that specifically describe the categorization of meat and (new) meat substitutes for new product development. Other researchers have looked into categorization of foods to learn more on the processes involving categorization, e.g. on cross-classification by Ross & Murphy (1999), on children's development by Nguyen & Murphy (2003), and on family resemblance by Ward & Loken (1986). Categorization was also applied to identify food perceptions for improving dietary measures, education and communication (Beltran[1] et al., 2008; Beltran[2] et al., 2008; Brown-Kramer, Kiviniemi, & Winseman, 2009), and to study the effect of eating context (Blake, Bisogni, Sobal, Devine, & Jastran, 2007, Blake, 2008). In the sensory field, sorting tasks are used for sensory description and to study differences between experts and naive consumers (Falahee & MacRae, 1995 & 1997; Lawless, Sheng, & Knoops, 1995; Lawless, Vanne, & Tuorila, 1997; Lelièvre, Chollet, Abdi, & Valentin, 2008; Tang & Heymann, 1999).

Besides the versatile use of categorization in consumer research, these studies have also shown that the food domain can be organized in several manners compared to categorization of non-food products (Ross & Murphy, 1999). Different ways for classification of foods have been described: thematic (e.g. cereal and bowl; Lin & Murphy, 2001; Murphy, 2001), and ad hoc or goal-derived (e.g. things to take on a picnic; Barsalou, 1983), while Blake et al. (2007) distinguished personal-experience-based, context-based, and food-based classifications. Most characteristic for foods is the spontaneously grouping in both taxonomic (e.g., dairy products, meats, vegetables) and script categories (based on a time or situation in which the food is eaten, e.g., appetizers, desserts, and dinner foods), which is called cross-classification (Nguyen & Murphy, 2003; Nguyen, 2007; Ross & Murphy, 1999). The taxonomic categories seem to be more common and accessible, and are more likely to be used as a kind of neutral organization (Beltran[2] et al., 2008; Blake et al., 2007; Ross & Murphy, 1999). Moreover, within these taxonomic categories, meat or animal-based foods were separated from plant-based foods and the formation of meat categories was strongly present, similar to the findings in our study (Beltran et al., 2008; Blake et al., 2007; Ross & Murphy, 1999). Thus, classification into meat versus non-meat products seems to be a very principal way how a set of food products is considered by consumers.

The reason behind this strong taxonomic base for clustering meat as a basic food group is not entirely clear. Unfortunately, we did not empirically assess the perceived products attributes that underlie the sortings and typicality/similarity ratings (see also the discussion by Ward & Loken, 1986). Probably, consumers use stored information and certain assumptions about these products in classification. Taxonomic food categories appear to be more oriented towards the intrinsic properties of the foods, such as the origin, composition and nutritional value (Ross & Murphy, 1999). So these are implicit features of the meat category that consumers learn with the basic food groups. Learning the foods around us in basic food groups already begins at early age. It starts at 3 years with understanding, towards the ability to categorize into basic taxonomic groups at around 7-8 years (Beltran[2] et al., 2008; Horton & Markman, 1980; Rosch & Loyd, 1978). This also has to do with nutritional or commercial classifications that consumers are exposed to in daily life. Blake et al. (2007) found that participants cited government dietary recommendations (e.g. basic food groups such as Grains, Meats, Fruits) and grocery store organization as guides for the categorization they applied with foods. Given the fact that consumers roughly divide foods into animal and plant-based foods, and learn repetitively from early age on about meat as a basic food category, make it a difficult starting point for new meat substitutes to be regarded as an alternative for meat on the plate.

Opportunities for Novel Protein Foods: visual similarity and scripts

There are ways for new meat substitutes to get around the strong taxonomic categorization of meat. The complete separation of meat and non-meat products disappeared with processed products (like 'burgers', 'sausages', 'coated products'). A likely explanation is that these products are visually more similar: by visual inspection only, one can hardly tell the difference between for instance a vegetarian sausage and a meat-based sausage. Since the ingredients were clearly labelled on the product pictures (e.g. soy or pork), this cannot be the only reason. We believe these products deviate to a large extent from stereotypes of meat (e.g. the typical meat products steak or cutlet) due to the processing procedure. As a result, the sight of original animal flesh has disappeared, and thereby the taxonomic meat-oriented approach is not evoked. The product form becomes a more dominant feature than the product ingredient source. Thus, new meat substitutes that resemble processed meat products are more likely to be chosen as an alternative to meat.

The form of the product might also be used as a reference for a particular application in a type of meal – e.g. 'a burger with French fries on a weekend day' or 'a sausage with a traditional meal', which could be appropriate for both meat and meat substitutes (Elzerman, 2006). This corresponds with a script type of categorization. When products are grouped based on scripts, they link to the situation or time in which a

food is eaten. As a result, foods from different food groups can be combined into one category, for example meat and pasta in a main course grouping (Ross & Murphy, 1999). When a context is given with a product, script categorization is applied more frequently, for example the categories main dish or foods that go together (Blake et al., 2007). Thus, providing a meal context with a product might offer better chances for meat substitutes (Elzerman, 2006). When a meat substitute is seen as an obvious part of certain meals or usage situations, e.g. part of a sauce, this product is more likely to be chosen in that situation without being directly compared to meat.

The impact of categorization of new meat substitutes on replacement of meat

The acceptance of new sustainable meat substitutes should be seen from the perspective of choice making between alternative products (meat versus meat substitutes). This process has two-stages: first a smaller set of relevant products is formed from a large number of alternatives, secondly the product of preference is chosen from that set (e.g. Antonides & Van Raaij, 1998; Nedungadi, 1990; Ratneshwar and Shocker, 1991; Urban, Hulland, & Weinberg,1999). Novel Protein Foods need to qualify for these two stages in order to be successful. In this study we only examined part of the first stage, based on visual information only.

The results indicate that Novel Protein Foods that are radically different in appearance from meat are not recognized as an alternative, but as another type of meal component. The appearance of a product does play an important role in how a product is categorized (Creusen & Schoormans, 2005; Schoormans & Robben, 1997). New products are usually compared against previously encountered products (e.g. Michaut, 2004; Van Trijp & Van Kleef, 2008) so in this case meat products are the reference. A high degree of resemblance of the new product -e.g. Novel Protein Foods- to the reference -e.g. meat- will facilitate that the new product is placed in an existing category (which is called assimilation), while a low degree of resemblance will result in formation of a new separate category. A new product being categorized in an existing category has several advantages: an easier identification and higher experienced certainty by consumers, a transferral of knowledge about the existing category to the new product (in case of meat and meat substitute for instance the fact that these are high protein products), and transferral of affect (the liking for meat is passed onto meat substitutes) (e.g. Gregan-Paxton, 2001; Gregan-Paxton & Moreau, 2003; Loken & Ward, 1990; Moreau, Markman, & Lehmann, 2001; Murphy & Ross, 2005; Ross & Murphy, 1999; Schoormans & Robben, 1997; Urban et al., 1999).

What should Novel Protein Foods then look like in order to be categorized with the existing categories of meat? Michaut (2004) described in her literature review on categorization of new products how resemblance can be reached by similarity and analogy. Similarity refers to sharing certain attributes (e.g. in appearance, Novel

Protein Foods and meat both having a red colour) while analogy addresses shared relations (e.g. the new and familiar product having a shared goal or script). In our study we incorporated some new concepts of Novel Protein Foods that were, given the results, too dissimilar to meat. Meyers-Levy & Tybout (1989) found that products that slightly differ from the prototype are evaluated more positively than products that are either very typical or very atypical. So when a target product is perceived as too similar to or as too dissimilar from the reference product, it may not be given further consideration (Schoormans & Robben, 1997; Wansink, 1994). This delicate balance needs to be found yet for Novel Protein Foods, and further research with products systematically ranging in similarity to meat is needed.

Further methodological considerations

The selection of test products by the research team may have influenced the outcomes of the study. There are also ways to involve participants in the selection process. Rosch and Mervis (1975) developed a procedure for measuring family resemblance, which involves an elicitation step and listing of attributes by participants. Ross & Murphy (1999) studied the categorization of foods in a series of successive studies, in which they for example also checked the relevance of the generated categories by a rating task. Due to practical constraints we were not able to involve consumers in the selection for the questionnaire (Step 1). We started the free sorting with a wide variety of products as consumers would chance upon a supermarket shelf. In addition, an elicitation task with these types of relatively new products would probably have resulted in a poor selection and focus on products that are regularly consumed.

We used cards with pictures of unpackaged and unprepared products, but with ingredient labels, as stimuli. We chose for this approach because we wanted to avoid effects of the brand and other packaging information (e.g. colour of the pack). This is of course a deviation from a real life situation, and how products are presented in a supermarket. In interpreting the results of this study, it has to be taken into account that there was probably more emphasis on the type of ingredient than with a product in its original commercial package. Labelling a food product with new and familiar ingredients obviously has an effect how these products will be categorized, as Tenbült, De Vries, Dreezens, & Martijn (2007) demonstrated with labelled GM foods versus unlabelled foods.

A set of commercial products of different varieties was used as stimuli, such as several types of burgers, schnitzels etc. The level of abstraction of the chosen stimuli can also influence the output of the categorization task. Blake et al. (2007) were interested in the entire food domain and applied different levels of categories in the stimuli, including subordinate level categories (e.g., french fries), basic level categories (e.g., potato), and superordinate level categories (e.g., vegetable). From a research

perspective, it would also have been interesting to see how meat and meat substitutes are categorized together with other products and food categories, especially with respect to the protein component in a meal (e.g. fish, nuts, legumes).

Conclusions and implications

In order to achieve a successful replacement of meat by new sustainable meat substitutes so called Novel Protein Foods, consumers need to recognize these products as a substitute for meat. Recognition of new alternative food products by consumers involves the process of categorization. In this respect, meat substitutes have a difficult starting point. Meat products are strong taxonomic categories based on the type of animal source, which subsequently leaves out meat substitutes from these categories. However, there are ways to get around this. Firstly, meat substitutes can be seen as fellow category members of processed meat products. The similarity in appearance is higher, and it avoids direct comparison to typical meat products like a steak. Secondly, these processed products have a more similar usage application in meals. Meat and meat substitute then share a script or goal category, which can even be employed further by providing a certain context. This can be implemented in package design, communication, but also in shelf positioning. Desai & Ratneshwar (2003) demonstrated how buying intentions of product variants significantly increased when a-typical product variants were placed in goal-based shelf displays instead of taxonomic shelf displays. In the third place, for product design of Novel Protein Foods an optimum level should be achieved with respect to similarity to meat: not too similar (to stay unique) but certainly not too dissimilar (to be recognizable as a substitute for meat).

Appendix 4.A: The co-occurence matrix of the test products

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	27	28	29	30	32	33	34	36	37	40	41
1. Sausage	34	10	2	9	9	3	3	31	1	9	1	8	4	2	8		19	19																	8	
2. Cutlet		34	13	20	20	6	4	9	3	16	11	11	20	8	12					1	1	1	2		2		2		1				1	1	11	1
3. Chicken drumsticks			34	4	4	3	2		20	4	29	1	12	5	1					1	1	1	2		2		2	1	3				1	1	1	11
4. Bacon slivers				34	33	9	6	9	15	19	4	10	7	4	10	7			7							4		2			7	7			10	
5. Nasi meat pieces					34	8	6	9	16	19	5	10	7	4	10	8			8							3		2			8	8			10	
6. Minced beef						34	18	1	5	4	4	1	19	21	1	2			2					2		12			1	2	2	2			1	
7. Minced balls							34	1	4	6	3	1	15	15	1	1			1					15	1	3		1	2	14	1	1			1	
8. Smoked sausage								34		9		10	1	2	10	1	21	21		1	1	1		1	1	1			1			1	1	1	10	1
9. Chicken pieces									34	6	23		3	1		7			7							2		2	1		7	7				10
10. Satay										34	3	11	6	5	11	2			2		1		1	1		1	1	15	1	1	3	2	1	1	11	1
11. Chicken fillet											34	1	12	5	2	2			2	1	1	1	2		2	1	2		2		2	2	1	1	1	11
12. Schnitzel												34	2	7	28	1	1	1		12	16	15	10	2	7	1	10	1	8	1		1	14	15	28	19
13. Steak													34	22	3					1	1	1	2		2		2		1				1	1	2	1
14. Hamburger														34	6	1	1	1		5	5	5	7	2	8	3	7		5	1		1	7	5	8	8
15. Cordon bleu															34	1	1	1		12	16	12	8	4	8	3	7	2	10	2		1	12	13	28	16
16. Nasi pieces V																34	3	3	20	2	2	13	1	2	2	8	1	4	2	1	17	33	2	2	1	1
17. Smoked sausage V																	34	34	2	3	3	2	6	3	8	3	6	5	3	5	2	2	3	3	1	1
18. Veg Sausage V																		34	2	3	3	2	6	3	8	3	6	5	3	5	2	2	3	3	1	1
19. Tofu pieces V																			34	10	8	1	3	9	4	18	3	5	9	4	27	21	8	8		
20.Veg Cordon bleu V																				34	28	20	14	11	13	11	15	1	17	1	11	2	28	29	12	13
21. Veg Schnitzel V																					34	20	14	12	12	10	14	2	21	2	9	2	27	28	12	13
22. Quorn fillet V																						34	11	4	12	2	13	2	10	1	2	13	17	19	11	10
23. Vegetable burger V																							34	5	17	2	29	10	12	11	4	1	19	15	10	12
24. Veg balls V																								34	11	13	6	8	19	23	10	2	12	11	3	3
25. Lentil sticks V																									34	6	21	10	18	12	6	2	13	11	8	8
27. Veg mince V																										34	2	5	12	6	18	8	9	9	2	1
28. Falafel burger V																											34	8	11	9	4	1	19	15	9	12
29. Veg satay V																												34	6	18	6	4	2	2	2	1
30. Veg nuggets V																													34	10	11	2	19	18	8	9
32. Vegetable balls V																														34	3	1	4	3	2	2
33. Tofu slivers V																															34	16	9	9		
34. Quorn pieces V																																34	2	2	1	1
36. Veg Burger V																																	34	29	15	17
37. Javanese burger V																																		34	17	14
40. Satay burger																																			34	19
41. Chicken burger																																				34

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Chapter 5

Meat or Meat substitutes … satisfaction guaranteed?

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ABSTRACT

For the development of new alternatives to meat, we were interested in the satiating power of current meat substitutes. A product inventory on commercially available meat substitutes on the Dutch market (107 products) showed that the majority (72 products) had a relatively low protein content compared to meat products. In line with previous research findings, an actual consumption study confirmed the important effect of protein content on satiety feelings. Using a pre-load test meal within-subject design, 28 participants tested 2 types of high protein meat substitutes, 2 low protein meat substitutes and 2 meat products. The results indicated that high protein meat substitutes were able to induce higher feelings of satiety than the selected meat products. However, consumption of low protein meat substitutes resulted in lower satiety feelings. We suggest that for a true replacer for meat, the protein content of meat substitutes need to be considered in product development since 'satiety' is a consumer-relevant quality attribute.

5.1 MEAT AND MEAT SUBSTITUTES

Is a meal complete without meat? Most people would probably say 'no' to this question: meat or meat products are still considered an important part of the meal (Holm & Møhl, 2000; Meiselman, 2000). Looking at the data in the Netherlands: there were only slight decreases in meat consumption over the past years and the market share of meat as a hot meal component is around 75% (Centraal Bureau voor de Statistiek, 2008; PVE, 2003; PVE 2009). Compared to other products in the food domain, meat is obviously considered a relatively high-value product that offers important quality aspects. Reasons for this success are considered both sensory and nutritional properties. Sensory properties that are drivers of liking of meat are typically good taste, good smell and certain texture especially tenderness and juiciness (Grunert, Bredahl & Brunsø, 2004; Issanchou, 1996). From a nutritional viewpoint, meat is an important provider of protein, vitamin B12 and iron and considered beneficial for good health (Givens, 2005; Southgate, 2000).

However, the production and consumption of meat has been debated in recent years and led to more conscious decisions by some consumers (Berndsen & Van Der Pligt, 2004; Grunert, 2006; Lea & Worsley, 2001; Verbeke & Viaene, 2000). This trend has boosted the market for alternatives: meat substitutes. These plant-based protein-rich products have traditionally been used by vegetarians mostly because of compassion for animal welfare (McIlveen, Abraham, & Armstrong, 1999). But nowadays these meat substitute products are appealing to a wider range of consumers, including those cutting out or cutting down on meat for a number of reasons, such as healthy eating, weight reduction, moral issues, environmental concerns and food safety (Davies & Lightowler, 1998; Hoek, Luning, Stafleu & De Graaf, 2004; McIlveen et al., 1999; Sadler, 2004).

Despite this trend, the replacement of meat by meat substitutes in the diet is still a very small proportion (only 1% market share) with the current meat substitute product portfolio in the Netherlands (Biologica, 2006). In order to seize the current opportunities for development of new alternatives to meat, it is of importance to consider which product characteristics play a role in food product choice. Two important product-related factors in the choice of foods by consumers are the sensory perception of physical-chemical properties of foods and the physiological effects of foods (Shepherd, 1989). With respect to meat and meat substitutes – mainly the sensory quality attributes have gained attention so far. For development of successful new meat substitutes, being able to mimic the sensory properties of meat is obviously considered as the Holy Grail (Elzerman, 2006; Hoek et al., submitted for publication, Chapter 3b; Kuntz, 1995; McIlVeen et al., 1999; Wiebe, 2004). However, an important physiological result of eating as perceived by consumers is the feeling

of satiety or being full. Compared to sensory properties, less is known about the role of satiety after consumption of meat substitutes compared to meat. A few studies have been published on the satiating effect of selected products chicken vs. Quorn or tofu (Burley, Paul, & Blundell, 1993; Turnbull, Walton, & Leeds, 1993; Williamson et al., 2006). These studies indicated that feelings of satiety induced by these products are similar to that induced by chicken. However, in a qualitative study and a large-scale quantitative consumer survey on attitudes towards meat substitutes in general, respondents indicated that meat substitutes were not filling sufficiently (Hoek, 2006; Hoek et al., submitted for publication, Chapter 3b). As one respondent commented: 'When I have vegetarian hamburgers, I always eat two'. In our previously performed survey, meat substitutes scored significantly lower for satiating properties compared to meat, especially by consumers that ate meat frequently (Hoek et al., submitted for publication, Chapter 3b).

It is currently not clear whether meat substitutes are actually less satiating than meat. The objective of this study is to obtain a better understanding whether there are differences in satiating effect by these products, and which product characteristics could be involved. We firstly identified the critical ingredients that have an effect on satiety by literature review. Secondly, we made a screening of the current meat substitute assortment for these ingredients. Lastly, based on this information we performed a consumption study in order to measure satiating effects by a number of meat substitutes.

5.2 IDENTIFICATION OF PRODUCT CHARACTERISTICS THAT AFFECT SATIETY

The first step to sort out whether satiety feelings after consumption of meat substitutes are different from meat consumption is to establish the general concept of satiety, how to measure this, and which nutrients are involved.

5.2.1 What is satiety and satiation?

The feeling of hunger is an important factor on what, how much and when we eat. While eating, the feeling of hunger is reduced under the influence of physiological processes and by feeling full further consumption is stopped. This process that occurs during the course of eating is called satiation (Benelam, 2009; Blundell, 1991; Blundell & Rogers, 1991; Gerstein, Woodward-Lopez, Evans, Kelsey, & Drewnowski, 2004). The term refers to Latin origin: satiare – satis which means 'enough'. Satiation (*intrameal satiety*) develops during a meal and ends the period of eating. It therefore limits the amount of energy consumed during that meal. Satiety (*intermeal satiety*)

on the other hand, develops after ingestion of foods and delays the onset of the next meal (Benelam, 2009; Blundell, 1991; Blundell & Rogers, 1991; Gerstein et al., 2004; Le Magnen, 182; Reid & Hetherington, 1997; Van Itallie & Vanderweele, 1981). How much the food is liked, thus the pleasantness of the food, only plays a role on satiation but not subsequent satiety, as demonstrated by De Graaf, De Jong, & Lambers (1999). A third phenomenon is sensory specific satiety, which relates to a decline in the palatability of a specific food item or food component compared to items or components that have not been eaten (Rolls, 1986; Rolls, Rowe, & Rolls, 1982; Rolls, Rolls, Rowe, & Sweeney, 1981). This is believed to be associated to the sensory characteristics of the food and the underlying mechanism is neural and not physiological (Reid & Hetherington, 1997).

These three different effects are studied in different experimental designs (Table 5.1). To assess satiation, certain foods are provided from which subjects can eat *ad libitum* until they feel full (e.g. Benelam, 2009; De Graaf et al., 1999; Hetherington, Foster, Newman, Anderson, & Norton, 2006; Porrini et al., 1997; Zijlstra, De Wijk, Mars, Stafleu, & De Graaf, 2009). The main outcome measure is thus the amount of eaten foods. To assess the effect of sensory specific satiety, typically the hedonic response (before and after eating) is being measured (e.g. Havermans, Geschwind, Filla, Nederkoorn, & Jansen, 2009; Hetherington, Rolls, & Burley, 1989; Rolls & Rolls, 1997; Sørensen, Møller, Flint, Martens, & Raben, 2003; Vandewater &Vickers, 1996). In studies on satiety, a preload experimental design is used in which participants consume a fixed amount of preload (the food under investigation) after which feelings of hunger and appetite are measured with regular intervals after eating (e.g. Benelam, 2009; De Graaf, Hulshof, Weststrate, & Jas, 1992; Kissileff, 1985; Reid & Hetherington, 1997; Turnbell et al., 1993). The amount eaten during a test meal after consumption of the preload, gives also an indication of the satiety effect of the preload. Thus, a food that is reported to have high satiety results in a longer time period between two meals or eating occasions in which the individual does not experience hunger.

Table 5.1: Concepts of satiety and satiation

Term	Description	Research design	Outcome measure
Satiation	Intrameal satiety: the sensation of fullness during an eating episode that contributes to stop eating.	Ad libitum foods or meal	- hunger scores before and after eating - eaten amount
Satiety	Intermeal satiety: the sensation of fullness between eating episodes that inhibits initiation of eating.	Preload-test meal design	- hunger scores between preload and test meal - amount eaten of test meal
Sensory specific satiety	The change in hedonic response to the sensory properties of a particular food as it is consumed	Ad libitum foods or meal	- hedonic ratings before and after eating - eaten amount

Nutrients involved in satiety and satiation

Foods with different compositions, specifically macronutrients, have different effects on satiation and satiety independent of their caloric value. Many experimental studies have been carried out over the past years, in which different food components, foods or meals, and subjects (animal or human) were used (see reviews of Benelam, 2009; Blundell & Burley, 1987; Halton & Hu, 2004; Reid & Hetherington, 1997; Slavin & Green, 2007; Stubbs, Ferres, & Horgan, 2000; Westerterp-Plantenga, 2008). For instance, already in 1970, Boot, Chase, & Campbell (1970) provided a lunch and snack to nine individuals that were either high or low in protein. They found that a protein-rich meal decreased subsequent food intake up to 3 hours later by 26% more than a carbohydrate-rich, isocaloric meal. Porrini et al. (1997) used in their studies manipulated omelettes that only differed in protein and fat content, and reported that high protein foods had a higher effect on both intrameal satiation and postingestive satiety than the high fat food. From a study using rats as subjects, Burton-Freeman, Gietzen, & Schneeman (1997) concluded that both fat and protein have a significant influence on satiety. Due to different procedures used in studies, variation in amounts, times between preload and test meal, or palatability of the food items, research findings are not always consistent or easy to compare (Benelam, 2009; Reid & Hetherington, 1997). Stubbs et al. (2000) reported in an extensive review of over 130 papers that there is a hierarchical effect on satiety in the order of protein > carbohydrate > fat. Although there is less consensus on carbohydrates and fat, most studies do indicate that the strongest effect on both satiety and satiation is caused by protein. It is now generally recognized that energy from protein has a greater effect on satiety than an equal amount of energy from carbohydrate or fat (Benelam, 2009; Gerstein et al., 2004; Westerterp-Plantenga, 2008). The effect of carbohydrates on satiety largely depends on the form of the carbohydrate. In particular it has been shown that the fibre content also positively influences satiety feelings and satiation (Blundell & Burley, 1987; Slavin & Green, 2007). Also other factors such as the weight, volume and water content seem to have an effect on satiety although this is less clear for satiation and data is not yet conclusive (Almiron-Roig, Chen, & Drewnowski, 2004; Benelam, 2009; Drewnowski & Bellisle, 2007; Poppit & Pentrice, 1996; Porrini, Crovetti, Riso, Santangelo, & Testolin, 1995). The main focus in terms of satiety lies therefore on relative protein and fibre content.

5.2.2 Inventory of meat substitutes with respect to satiating ingredients

The basic question of our study is whether consumption of meat substitutes results in low satiety feelings compared to meat. We therefore considered the composition of meat substitutes focusing on the potent factors on satiety: the protein and fibre content.

We made a product inventory of meat substitutes on the Dutch market. Only products were included that provided nutritional values on pack or via producer. Product compositions (energy, protein, fat, carbohydrate and fibre content) were compared between 107 different products of 6 leading brands. The types of products included in the inventory varied from stir-fry pieces to burgers, and from soy based products, mycoproteins to vegetable based products. The differences in nutritional values within the meat substitute category are remarkable, and are even apparent within one brand. Table 5.2 demonstrates the great variety in nutritional composition in the assortment of meat substitutes. Comparing this to meat, Table 5.2 shows that meat products have in general a higher protein content than meat substitutes. Although some of the meat substitutes have comparable protein levels to meat, we found that only 10% of the meat substitutes investigated had a relative protein content > 0.13 g/kcal, while this accounted for more than 60% of the meat products.

The large variations in relative protein content within the meat substitute category might play a significant role in differing satiety feelings after consumption. The vast amount of meat substitutes with a relatively low protein content could also explain the reported negative perception of satiety by meat substitutes compared to meat products.

Table 5.2: Nutritional composition of meat substitutes and meat

	Meat substitutes[a]	Meat[b]
Key ingredients[c]	Cheese, corn,egg-protein, lentils, milk protein, mycoprotein, pea, potato starch, rice, soy, vegetables, vegetable oil, wheat, wheat protein	Animal protein, fat
Energy: median / range (kcal per 100g)	210 (70 - 342)	151 (110 - 378)
Protein: median / range (g per 100g)	14 (4 - 34)	21 (16 - 35)
Relative protein content[d]: median / range (g per kcal)	0.06 (0.04 - 0.19)	0.14 (0.05 - 0.23)
Fibre: median / range (g per 100g)	3.2 (0.1 - 7.4)	-

[a]based on 107 unprepared meat substitute products from 6 brands in the Netherlands: Tivall, Quorn, Planet Green, Sofine, BeGood, Valess.

[b]based on the 72 unprepared raw meat products listed in the Dutch Food Composition database (NEVO, 2006). The inventory includes poultry, but excludes organs and highly processed meat products, such as sandwich fillings.

[c]List displays full range of key ingredients of all products investigated in alphabetical order.

[d]Note that the relative protein content is related to satiety.

Some specific product examples of meat substitutes from this inventory; Tivall vegetarian eco veggie-burger contains per 100g: 134 kcal, 9 g protein, 6 g fat, 11 g carbohydrates and 3 g fibres, while Tivall vegetarian sausages contain per 100 g: 262 kcal, 15 g protein, 20 g fat, 5,5 g carbohydrates and 1.2 g fibres, and Quorn minced meat: 79 kcal, 12 g protein, 2,8 g fat, 1.4 g carbohydrates and 4,9 g fibres.

5.3 CONSUMPTION STUDY TO INVESTIGATE SATIATING PROPERTIES OF MEAT SUBSTITUTES

We described above that survey respondents indicated that meat substitutes have a lower satiating power than meat (section 5.2.1) and that a part of the meat substitute category has low levels of protein, which plays an important role in satiety feelings (see section 5.2.2). Therefore, we performed a consumption study to investigate this further. Aim of the consumption study was to assess whether there are differences in satiety feelings after consumption of meat substitutes with higher protein levels compared to products with a low relative protein content. In addition, we wanted to explore how the satiating effects of meat substitutes compare to those from meat products.

5.3.1 Methodology of the consumption study

The study design was a preload-test meal within-subject design in which 6 products (either meat or meat substitutes) differing in relative protein content were compared for their satiating effect under realistic conditions.

Participants

Non-vegetarian students (n = 28, 7 males) joined in a consumption experiment during 6 days. The majority (n = 18) were frequent users of meat substitutes (consumption of 3 times per week or more). Individuals that were vegan or vegetarian could not participate because it was required to eat meat products during the study. Other exclusion criteria were being underweight (Body Mass Index (BMI) <18 kg/m2), overweight (BMI >25 kg/m2), or having a dietary restrained eating behaviour [restrained eating scores <2.38 for men or <3.25 for women], as assessed by The Dutch Eating Behaviour Questionnaire (Van Strien, Frijters, Bergers, & Defares, 1986), since these could affect reporting of satiety feelings. Participants received 80 euro after full completion of the study.

Samples

Preloads — We aimed for a realistic setting of the test, and since meat substitutes are usually eaten during a hot meal, we chose for an entire meal as a preload instead of testing single products that are rarely eaten separately (Meiselman, 1992). The preloads thus consisted of meals with varying meat -substitute- products and other meal components that were kept constant. The energy content of the meal was based on the average energy content of a Dutch lunch meal: for men 570 kcal and for women 450 kcal (Kistemaker, Stafleu, & Hulshof, 1998). So besides the meat -substitute- products under investigation, the preload meal also consisted of a salad and mashed potatoes, which were chosen because they are relatively low in energy and fibre content (see Appendix 5.A and 5.B).

Meat and meat substitutes in preloads — We used meat -substitute- products that were not manipulated but actually commercially available at the Dutch market. To investigate how protein level plays a role in the satiating effect of these products, we aimed for products in the test that differed as much as possible in protein content (En%). First, the selection of meat substitutes was made. The range in protein content of meat substitute products that were available was 0.04 g/kcal to 0.19 g/kcal. Based on this existing range we defined 'low protein level' as <0.08 g/kcal protein and 'high protein level' as >0.13 g/kcal protein. Two different meat substitute products of the low protein level category and two meat substitute products of the high protein level were chosen (Table 5.3). Since the focus of the study was on the satiating effect of products varying in protein content, we selected products that minimally differed in volume, energy or fibre content. (The maximum difference between selected products was 9 kcal and 2 g fibre per 100 g, see Table 5.3). Other criteria for the selection of products were: possibility to heat it in an oven (in order to keep to amount of baking oil to a minimum and constant across products), and not spicy or in a sauce. Secondly, meat products were selected because we were also interested in how the satiating effect of meat substitutes relates to that from meat products with the same caloric value. Following the same selection criteria, the available meat products within the range of 190 to 200 kcal per 100 g were minced meat and a hamburger. These meat products have protein levels in between the high protein and low protein meat substitutes. The amount of meat (substitute) product in the preload meal was 250 g for men and 200 g for women. As a result of the selection of different types of meat substitute products, there was a vast difference in the protein content of the preload meal: the high protein preload meal contained 50% energy from protein and thus can be considered as high protein meals. (Meals with on average 20% to 30% of energy from protein are representative for high protein diets – see Veldhorst et al., 2008; Westerterp-Plantenga et al., 2006). The low protein preload meal consisted of 15% energy from protein, and had thus 50 g less protein on the plate than the high protein preload meal (see Appendix 5.B).

Test meals

The test meal consisted of a typical Dutch lunch: a bowl with sandwiches –wholegrain bread rolls with cheese (90 kcal each), jam (85 kcal each), nut spread (103 kcal each) or white bread roll with cheese (104 kcal each). (Individuals had indicated their preference for type of bread roll at the enrolment of the study). There was an excess in the amount of sandwiches (for men 15 pieces and for women 10 pieces) to make sure that *ad libitum* consumption was possible. In addition, a non-regular size of bread roll was used (20 grams instead of 40 grams) to reduce cognitive effects in the chosen amount. Bread rolls that were not eaten completely were weighed.

Table 5.3: Overview of the test products

Product (Abbr.)	Product type	Energy (kcal/100g)	Protein (g/100g)	Fibre (g/100g)	Protein (g/kcal)	Rel. protein content*
Beefstyle pieces (TB)	Meat substitute	185	28	4	0.15	'high'
Stirfry pieces (VR)	Meat substitute	190	28	4	0.15	'high'
Italian Burger (IC)	Meat substitute	190	8.3	3	0.04	'low'
Vegetable Schnitzel (GS)	Meat substitute	190	8.0	3	0.04	'low'
Minced meat (GB)	Meat product	191	20	0	0.10	'medium'
Hamburger (HB)	Meat product	200	13	1.5	0.6	'medium'

*As referred to in this chapter (in g/kcal).
All vegetarian products (TB, VR, IC, GS) were based on wheat, soy and vegetables, and from the brand Tivall.

Procedure

The participants attended 6 sessions within 2 weeks. For each participant, one preload type was tested during one session. The procedure of one session is illustrated in Figure 5.1. Since baseline hunger ratings were recorded before consumption of the preload, participants were allowed to have breakfast at home but a similar breakfast was required during session days. After breakfast, only low-calorie drinks were allowed for consumption. Participants were also asked to keep evening meals and activity levels on the day before the test similar throughout the study period. The consumption sessions were held in a realistic eating environment, namely a dining room with buffet, from which participants collected the foods to be tested. Foods were eaten from normal plates and cutlery. In order to keep activity levels as low as possible, participants remained at, or close to, the test room and could bring reading material or watch videos.

Preloads were unlabelled and the order of presentation of meat or meat substitutes within the preload was randomized for each participant. Participants were obliged to finish the whole meal and drink 2 glasses (2 x 250 ml) of noncarbonated water. Time between preload and test meal was set at 2,5 hours based on previous studies with comparable energy content of preloads (500 kcal) (see Reid & Hetherington, 1997) and a pre-test (n = 8). Each person was provided with a timer for the whole afternoon. Just before (t = 0) and every half hour after consumption of the preload (t = 1 to t = 6), participants filled out a questionnaire assessing satiety ratings: hunger ('How hungry are you?'), fullness ('How full do you feel?'), desire to eat ('How great is your desire to eat') and prospective consumption ('How much could you eat?') on 100 mm visual analogue scales (VAS) scales anchored not hungry – extremely hungry, and so on.

Right after t = 6, the test meal was provided. Participants were instructed to eat as many or few until feeling comfortable, and to finish one glass of water (250 ml).

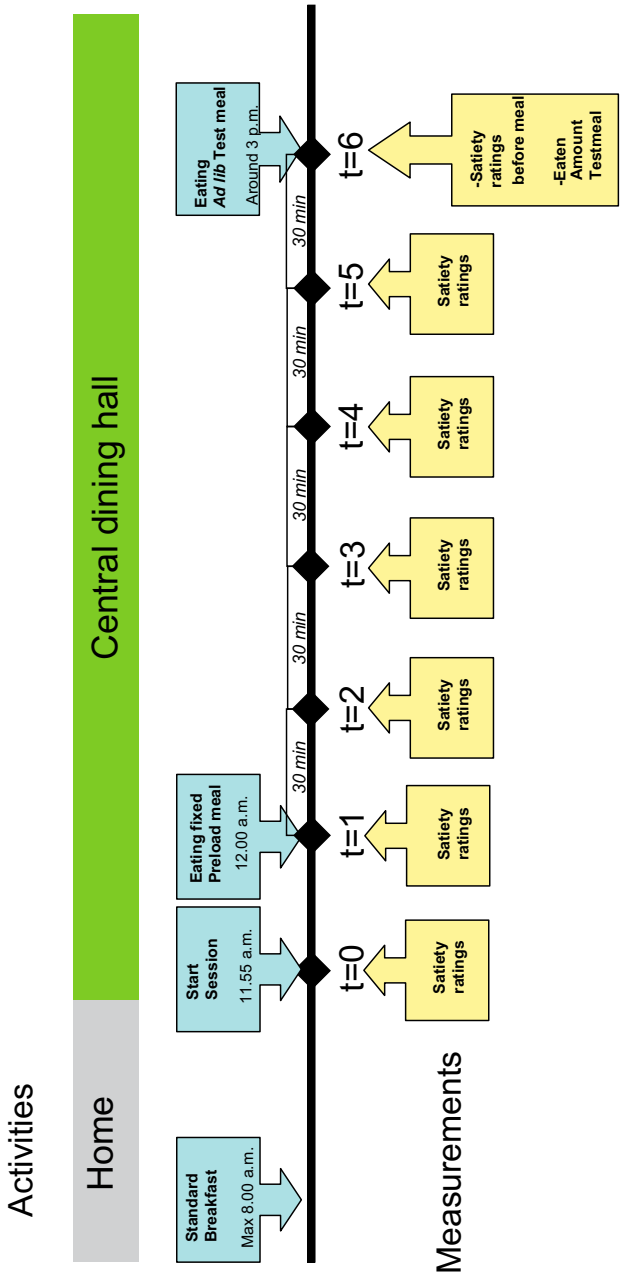

Figure 5.1: Study procedure of a product test session

Data analysis

Relative scores for hunger, fullness, desire to eat, and prospective consumption were calculated at individual level by subtracting the baseline score (t = 0) from each of the scores at time points t = 1 to t = 6. We calculated for each individual the maximum feeling of satiety reached within a product consumption session by determining the minimum reached satiety rating for hunger, desire to eat and prospective consumption. For the fullness rating the maximum reached value was calculated. These values are referred to as the 'maximum satiety values' in this chapter. The maximum satiety values and the eaten amount of test meal were compared between products by a non-parametric test (Kendall's W). Satiety ratings (hunger, fullness, desire to eat and prospective consumption) were compared between products by a repeated measures ANOVA with product, time and the interaction as independent variables and baseline values as covariate. Data-analyses were performed with SPSS 14.0 and *p*-values below 0.05 were considered as statistically significant.

5.3.2 Results of the consumption study

The typical course of hunger over time before and after eating is shown in Figure 5.2. Just before consumption of the preload (t = 0) participants were relatively hungry, while mean hunger scores dropped considerably right after consumption of the preload (t = 1). During the following 2,5 h (t = 1 to t = 6) hunger gradually restored. The figure shows that mean hunger feelings after consumption of a meal (t = 1) with high protein meat substitutes (TB, VR) were less compared to a meal with low protein meat substitutes (GS, IC). Restoration from full to hunger was comparable between preloads (based on visual inspection of Figure 5.2 slopes from t = 1 to t = 6). At the end of the session (t = 6) high protein preloads thus resulted in less hunger at group level. The spread in absolute scores was large however, for example right after consumption (t = 1) the following mean hunger ratings ± *SD* were recorded; meat products: HB 22 ± 20, GB 22 ±18, high protein meat substitutes: TB 18 ± 18, VR 13 ± 16, low protein meat substitutes: GS 24 ± 23, IC 26 ± 22.

Inspection of individual responses on the same preloads showed that the course of hunger ratings over time differed considerably between individuals, which explains the high standard deviations on each recorded time point. Despite differences in the *height* of ratings, Figure 5.3 also shows that *the moment* at which the least hunger (the most fullness) was observed differed as well: participant 6 (left) felt most full right after consumption (t = 1) while for participant 21 (right figure) this was rated at t = 3. We therefore compared the maximum satiety value (lowest relative hunger rating after consumption of the preload) between preloads and found significant differences ($p < 0.02$) (Table 5.4): meals with high protein meat substitutes contributed to higher maximum satiety ratings during the session than meals with low protein meat

substitutes. Results for ratings for fullness, desire to eat, and prospective consumption scales pointed in the same direction. In addition, results of the repeated measures analysis showed that there was a significant difference between products for fullness ratings ($p < 0.02$), and borderline significance for hunger ratings ($p = 0.06$) but not for desire to eat and prospective consumption ratings. The eaten amount during the test meal (after t = 6) was not statistically different between preloads (Table 5.4).

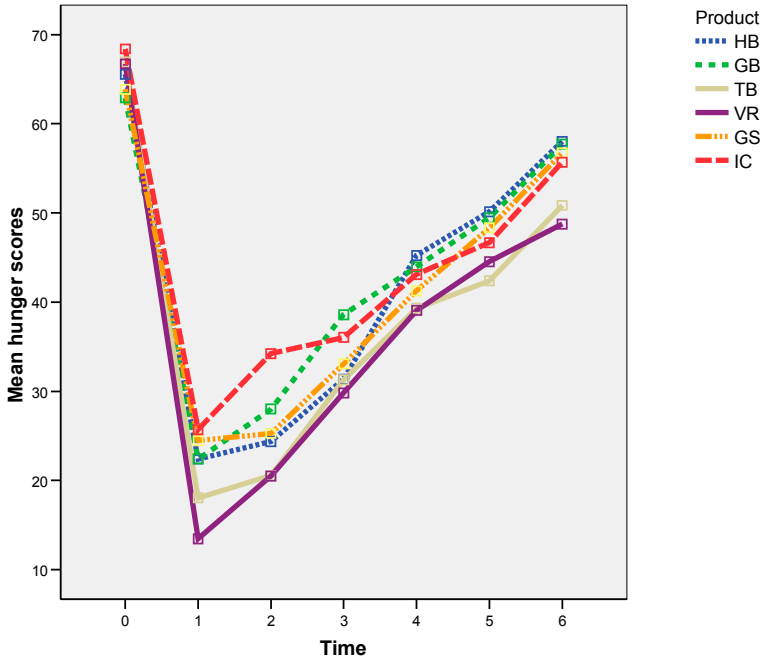

Figure 5.2: Absolute hunger ratings over time after consumption of a meal with meat products (HB, GB), high protein meat substitutes (TB, VR), or low protein meat substitutes (GS, IC)
(t = 0: just before consumption, t = 1: right after consumption of the preload, t = 2: 30 min after consumption, t = 3: 60 minutes after consumption, up to t = 6: 150 minutes after consumption).

Table 5.4: Satiety measures following consumption of a meal with either meat, high protein meat substitutes or low protein meat substitutes (mean ± *SD*)

Product type	Product	Maximum satiety score* (mm)	Eaten amount (kJ)
Meat	HB	-48 ± 23	1513 ± 795
	GB	-43 ± 21	1534 ± 899
High Protein meat substitute	TB	-54 ± 20	1545 ± 816
	VR	-55 ± 18	1412 ± 840
Low Protein meat substitute	GS	-45 ± 22	1467 ± 862
	IC	-43 ± 21	1573 ± 917

*Maximum satiety score in hunger ratings shows the mean of the lowest hunger scores displayed by each individual (corrected for baseline hunger).

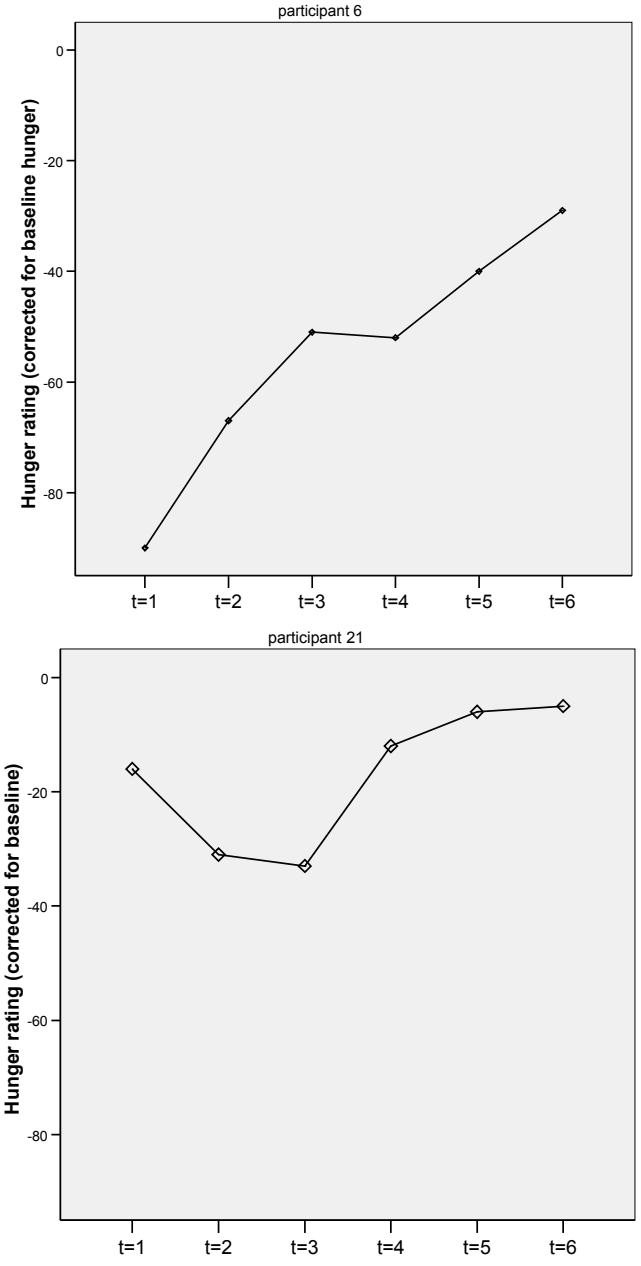

Figure 5.3: Individual relative hunger ratings over time
Graphs display scores of two participants after eating the same preload.
Hunger scores were corrected for individual baseline.

5.4 OVERALL DISCUSSION

For the development of new meat substitutes, we are interested in factors that influence a successful replacement of meat in the diet. A previous consumer survey indicated that consumers feel that meat substitutes are less satiating than meat (Hoek, 2006; Hoek et al., submitted for publication, Chapter 3b). At the start of this study it was not clear whether meat substitutes are actually less satiating than meat or whether this opinion on meat substitutes was merely based on certain beliefs or expectations.

The satiety literature generally states that protein is one of the key satiating components in foods. Considering the current meat substitute category, it is striking that our inventory demonstrated that there are large differences in protein content between these types of products: there are some meat substitutes that have a protein content similar or higher than meat, but the majority of products (around 90%) is relatively low in protein. We therefore performed a controlled consumption study in which participants rated how satiating both high protein and low protein meat substitute products were compared to meat products. The results suggest that a meal with low protein meat substitutes was less satiating than the same isocaloric meal with high protein meat substitutes. In addition, the high protein meat substitutes were even more satiating than the reference meat products with a medium protein content. Thus, it seems that some high protein meat substitutes do have the ability to generate high feelings of satiety after consumption, but these products are obviously not representative of the current meat substitute category.

Previous studies that have demonstrated an effect of higher protein levels on increased satiety have used mostly dairy products (drinkable or solid yoghurts, puddings, spreads, sometimes enriched with protein isolates), but also sandwiches, rice with either beef or fish sauce etc (e.g. Bertenshaw, Lluch, & Yeomans, 2009; Booth et al., 1970; Borzoei, Neovius, Barkeling, Teixeira-Pinto, & Rössner, 2006; Teff, Young, & Blundell,1989; Tsuchiya, Almiron-Roig, Lluch, Guyonnet, & Drewnowski, 2006; Uhe, Collier, & O'Dea, 1992; Veldhorst et al., 2009). Due to different study designs, conditions for participants, time between preload and test meals, amount of product, protein levels, and used satiety measures, it is difficult to compare effects between products across studies directly, let alone to transpose results on to other products. With respect to the satiating effect of meat substitutes compared to meat, previous studies used mycoprotein (Quorn), tofu and chicken as test products (Burley et al., 1993; Turnbull et al., 1993; Williamson et al., 2006). Conclusions were that meat substitutes from mycoprotein or tofu satiated more than chicken. It must be noted however, that the purpose and design of these studies were different than the study described in this chapter: these researchers tested meals that not only varied in the meat (substitute) component but also the other meal components varied and the

main study focus was on the effect of fibre. For instance, Williamson et al. (2006) used meals with either chicken, mycoprotein or tofu and varied the other meal components in such a way that the meals were ultimately equal in energy and protein. In that study, the mycoprotein meal consisted of 40 grams of mycoprotein with 8 g cheese added, and was compared to a meal with 20 g chicken. This is a relevant set up when studying the effect of fibre on satiety by different type of meals. However, working from the assumption that consumers compose meals by different meal components based on a certain volume (Meiselman, 2000; Wansink, Painter, & North, 2005), -thus having either a piece of meat or meat substitute on the plate- we think it is more appropriate to vary only the meat (substitute) component as we have done in our study.

A strong point of our study is thus that we have used a realistic setting as much as possible, which is necessary to put study findings in context of consumers' daily life practice. We have used commercially available products that were not manipulated by adding protein powder or other substances. We also used a natural meal setting in a canteen, without taking invasive physiological measures, which might influence normal eating and rating. However, we did use a relatively large amount of meat (substitute), 200-250 g, to enlarge the proportion of the product of our interest. A drawback of the realistic approach is that it is not possible to control every variable, which might have been the cause of the large standard variations and different patterns between individuals. Although there were guidelines for participants and self-reporting, we did not actively control their eating or sports activities the evening or morning before the study day. This could have resulted in the large differences between individuals in the course of hunger ratings after consumption of the same product. Since the timing between preloads and test meals is crucial to measure the satiating power of a product (Benelam, 2009; Reid & Hetherington, 1997), it might well be possible that this timeframe differs between individuals.

With respect to the choice of products, it was not possible to keep the fibre content between products completely the same, since products meeting the energy and protein criteria were simply not available. However, the somewhat higher fibre content of the low protein meat substitutes would have influenced the results in the right direction (without fibre they would have been even less satiating). In addition, the type of protein source might also play a role in the course of satiety. Veldhorst et al. (2008) in their review mention how different proteins may affect satiety differently, by implying different satiety mechanisms. Studies have looked into differences in satiating effects between casein, whey, soy, gelatine, gluten, egg albumen and pea, but outcomes have not been consistent or conclusive (Anderson, Tecimer, Shah, & Zafar, 2004; Benelam, 2009; Diepvens, Häberer, & Westerterp-Plantenga, 2008; Hall, Millward, Long, & Morgan, 2003; Lang et al.,1998; Lang et al., 1999; Veldhorst et al., 2009). Especially with respect to differences between meat substitutes (plant protein

source) and meat products (animal protein source), this is an interesting topic that needs further exploration.

Implications for product development of new meat substitute products

To decrease the environmental pressure caused by human consumption, one of the options is to reduce meat consumption by replacing meat in the diet by meat substitute products (Aiking, De Boer & Vereijken, 2006; Jongen & Meerdink, 2001). Taken into consideration that these type of products are eaten within a similar structure of meals as meals with meat (Elzerman, 2006; Meiselman, 2000), and rather take the place of meat in a dish, product developers need to consider the composition of such a substitute product.

Firstly, the nutritional value comes into play. Although meat is not considered as an essential part in the diet, it is an important provider of protein. Moreover protein from animal sources is of high quality, containing essential amino acids. Meat also provides vitamin B12, a vitamin only found in foods from animal source, and is a source of iron for which haem-iron facilitates the absorption of iron from all dietary sources (Southgate, 2000). As a result, current available meat substitutes have improved their nutritional profile by fortification with iron and B-vitamins (Davies & Lightowler, 1998; NEVO, 2006; Sadler, 2004).

Secondly, meat's unique flavour and texture (Grunert et al., 2004; Issanchou, 1996) has placed developers of meat substitutes for a technological challenge. In general, the sensory appreciation for meat substitutes is lower than that for meat and it is said that further growth of the meat substitute market is expected by improving the sensory quality (Elzerman, 2006; Hoek et al., submitted for publication; McIlveen et al., 1999; Sadler, 2004). Consequently, there is considerable attention to improve consumer appreciation for new meat substitute products by improving the flavour and texture properties (Aiking et al., 2006).

Finally, the satiating properties of new meat substitutes need attention. Research on the development of food products that increase feelings of satiety have a strong base and tradition in the area of weight management, such as with meal replacement drinks and bars, that help to control appetite (Benelam, 2009; Mela, 2006). Over the past few years functional foods or supplements have also appeared on the market, aiming to prolong the feelings of satiety when consumed together with normal food. According to Runestad & Lawlor (2005), satiety-inducing products offer a opportunity for manufacturers in new sectors to add protein to their products. As we have demonstrated in our study, satiety also matters in food products that are not eaten by exception (such as meal replacement bars) or as an additive supplement. The effect of products or meals that vary in protein content, and that are eaten in a normal diet, also have an effect on satiety, which is relevant to consumers on a day to day basis (Astrup,

2005). Eating a high-protein product or meal has not only an acute effect on satiety, but high-protein diets on longer term have shown to have an effect by continuously higher satiety for 24 h up to 5 days compared with a normal protein diet (see Veldhorst et al., 2008). This accounts for meat and meat products, which could be modified by adding ingredients to improve the nutritional quality (Fernández-Ginés, Fernández-López, Sayas-Barberá, & Pérez-Alvarez, 2005), but in particular for meat substitutes that are expected to deliver the same satiety feeling after consumption as meat. Since meat substitutes are processed products, this offers the opportunity to add protein or other technologically innovative ingredients that influence the satiety cascade (Irvine, Livingstone, & Welch, 2007).

Satiety experiences and expectations by consumers: further research needed

It must be noted that the feelings of satiety, after consumption of a food product are not only caused by physiological effects but are also under the influence of psychological factors, such as the person's knowledge, beliefs, expectations and emotions about the product. Thus, satiety feelings are not solely related to the macronutrient composition, nutrient density or bulk of the food itself, but also to acquired cognitive expectations (Bellisle, 2008; Wooley, 1972). Individuals have expectations beforehand about the satiety that is likely to develop after consuming certain products. Brunstrom, Shakeshaft, & Scott-Samuel (2008) discovered that there is a considerable mismatch between satiety expectations and the actual composition of foods. In an experimental set-up with a range of food products it was demonstrated that these expectations differed across foods: relatively familiar foods were expected to be more filling than unfamiliar foods that are eaten rarely. In addition, the expected satiety played an important and independent role in decisions about portion size. Kristensen, Holm, Raben, & Astrup (2002) also highlighted the importance of the qualitative dimension of satiety by a qualitative interview study investigating how appetite was experienced and handled in the context of everyday life. A crucial dimension in "proper" satiety (besides fullness, duration of satiety, and the pleasure of eating) was not related to the product itself but to the social context, such as eating at work or in spare time and whether company was present.

In line with these illustrations, we postulate that in the case of meat substitutes, psychological factors also play an important role in how consumers evaluate satiety by these products. Our previous consumer survey (Hoek et al., submitted for publication, Chapter 3b) indicated that respondents, who were unfamiliar with meat substitutes and actually never had eaten those, also rated these products as having a lower satiating power than meat products. Clearly, they must have had certain negative expectations on the properties of meat substitutes. Besides the role of unfamiliarity with meat substitutes, we think that meat is considered as the gold standard: meat is

still a dominant piece in everyday meals and seen as an essential part of a 'proper meal' (Holm & Møhl, 2000; Meiselman, 2000). Current meat substitutes are probably not regarded as products that can fulfil the same role as meat in a meal, and are therefore expected to be less satiating than meat. Since high-protein meat substitutes do have the potency to satiate similarly or even more than meat, there are opportunities to stress this aspect in communication to consumers.

To what extent cognitive factors influence the development of satiety and signals of satiety needs to be investigated further (Brunstrom et al., 2008; Kristensen et al., 2002; Reid & Hetherington, 1997). In further research on this topic, the use of biomarkers for satiety - physiological measures such as glucose, leptin or ghrelin levels in blood (see review by De Graaf, Blom, Smeets, Stafleu, & Hendriks, 2004) – could be used to differentiate the purely physiological from psychological influences on self-reported satiety feelings. Nevertheless, for purposes other than merely understanding physiological mechanisms of satiety, we think it is highly relevant to always include the subjective dimension, since this would better reflect the situation how consumers actually perceive satiating effects by food products.

Conclusion

For the development of new food products, which involves specification or optimisation of physical properties (both chemical and macro/micronutrient composition), usually consumer tests are performed that focus on the sensory aspects of the product. As we illustrated by this case study on meat substitutes, the satiating product properties need attention as well since satiety is a consumer-relevant quality attribute. Initial indications that consumers consider meat substitutes as a category of food products less satiating than meat, can be explained by the relatively low protein content of the majority of meat substitute products. In line with previous literature on satiety, we demonstrated that consumption of low protein meat substitutes products resulted in lower satiety feelings compared to high protein meat substitute products. In order to be a true replacer for meat on the plate, new meat substitutes should therefore have protein levels comparable or higher than meat products. Designing attractive foods with a high satiating power, and subsequent communication about this benefit, is an opportunity for processed food and meat industry that can be employed further.

APPENDICES

Appendix 5.A: The quantity of the preload meal components

Components	Men	Women
Meat -substitutes- (g)	250	200
Sauce (g)	19	15
Lettuce (g)	19	15
Cucumber (g)	19	15
Dressing (g)	6	5
Mashed potatoes (g)	50	40
Oil (ml)	8	6

Appendix 5.B: Nutritional value of the preload meals

	Men				Women			
Meal with meat -substitute-	Energy (kcal)	Protein (g)	Energy from protein (%)	Fibre (g)	Energy (kcal)	Protein (g)	Energy from protein (%)	Fibre (g)
Meal with TB	559	71	51	4	447	57	51	3
Meal with VR	571	71	50	3	457	57	50	3
Meal with IC	571	22	15	8	457	18	16	7
Meal with GS	571	21	15	8	457	17	15	7
Meal with GB	574	51	36	1	459	41	36	1
Meal with HB	596	33	22	4	477	27	23	4

TB = a 'high' protein meat substitute.
VR = a 'high' protein meat substitute.
IC = a 'low' protein meat substitute.
GS = a 'low' protein meat substitute.
GB = a meat product.
HB = a meat product.

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Chapter 6

Are meat substitutes liked better over time? A repeated in-home use test with meat substitutes or meat in meals

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ABSTRACT

We wanted to investigate whether meat substitutes would be better appreciated after repeated consumption. Non-vegetarian participants (n = 89) joined an in-home use test and consumed one type of product with their hot meal 20 times during 10 weeks: Quorn (meat-like), tofu (not meat-like) or a meat reference (chicken). Initial liking (100 mm scale) for chicken was higher (81 ± 19) than for Quorn (60 ± 28) and tofu (68 ± 21). Strikingly, after 20 exposures there were no differences between the products anymore. Boredom occurred with all three products, but the decrease in liking was most pronounced for chicken (68 ± 26 final session). However, there were different individual responses showing both 'boredom' and 'mere exposure' patterns. Mere exposure occurred noticeably more frequently with tofu. We also found that bored persons used more different types of meals, probably to alleviate product boredom. The study suggests that, at least for some consumers, liking of meat substitutes can be increased by repeated exposure.

6.1 INTRODUCTION

'Eating less meat may slow climate change'. This is not a claim on a meat package.... yet... but recent publications have reinforced and given attention to the relation of our food consumption patterns and the impact on the environment, especially for meat production (e.g. De Boer, Helms, & Aiking, 2006; McMichael, Powles, Butler, & Uauy, 2007; Vinnari, & Tapio, 2009). Therefore, options are being investigated to reduce the human consumption of meat. One of these options is to replace meat in the diet by plant-based alternatives to meat, so called Novel Protein Foods or meat substitutes (Aiking, De Boer, & Vereijken, 2006; Jongen & Meerdink, 2001). This can only be successful when these products are attractive to consumers, being directly competitive and substitutable for meat, and are consumed at sufficient amounts over a long period of time. However, this has not been the case yet.

Firstly, developing meat substitutes is a challenge from a technological point of view. Meat is a complex product with typical flavour and texture characteristics (especially tenderness and juiciness) that have a high influence on perceived quality and thus consumer appreciation (Grunert, Bredahl, & Brunsø, 2004; Issanchou, 1996). Currently, consumers judge the overall sensory quality of meat substitutes lower than meat (Elzerman, 2006; McIlveen, Abraham, & Armstrong, 1999) and *non*-vegetarian consumers prefer meat-like properties in a meat substitute (Hoek et al., submitted for publication, Chapter 3b). Secondly, it takes a certain amount of time before new technology-based food innovations will get accepted by a large group of consumers (Ronteltap, Van Trijp, Renes, & Frewer, 2007; Van Trijp & Van Kleef, 2008). Meat substitutes can be considered as relatively new food products in the assortment of protein-rich foods in Western European countries. These products, such as from wheat protein and mycoprotein, were only introduced 10 to 20 years ago (Davies & Lightowler, 1998; McIlveen et al., 1999; Sadler, 2004). The market share of this category has increased over time but is in the Netherlands still only 1-2% of the total meat market (Anonymous, 2004) and the frequency of use is also low compared to meat (Aurelia, 2002). In short, meat substitutes are faced with some challenges. In order to establish a durable replacement of meat by meat substitutes, it is necessary to understand which factors are important in long-term acceptance of these products.

Background on factors in long-term acceptance

Consider these actual comments of consumers about meat substitutes:

A. *'First you have to get used to it, but after a while I really got to like it more each time.'*

B. *'At first I liked the product, but when I ate it for the fourth time, it got bored with it'*

Repeatedly consuming a food can change liking for it in either way by showing an increase in liking (comment A) or decrease in liking (comment B) or no systematic changes (as reviewed by Zandstra, Weegels, Van Spronsen, & Klerk, 2004). An increase in liking response has been firstly explained by Zajonc (1968) who described that mere exposure to an unfamiliar stimulus can enhance one's attitude toward it. For more familiar products, such as staple foods like bread, milk, and butter, liking remains more often constant (Schutz & Pilgrim, 1958). How a decrease in liking after repeated exposure arises is less understood. Chung & Vickers (2007) listed the multitude of factors involved: the complexity of the food, initial liking of the food, the flavour intensity, hunger/fullness, and the amount of choice allowed. Both for boredom and mere exposure effects, a change in liking is obviously not just a time-dependent process but also depends on the type of stimulus and how this is received. Dynamics of liking should therefore be considered as an interaction between the product and the receiver.

Considering the role of the product, the degree of newness plays an important role in initial acceptance and acceptance over time (Hobden & Pliner, 1995; Pliner & Loewen, 1997; Pliner, Pelchat, & Grabski, 1993; Raudenbush & Frank, 1999; Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994; Tuorila, Meiselman, Cardello, & Lesher, 1998). New food products are often initially rejected, but with repeated exposure this initial rejection can be changed into acceptance (Birch, McPhee, Shoba, Pirok, & Steinberg, 1987; Birch & Marlin, 1982; Pliner, 1982). Bingham, Hurling, & Stocks (2005) described such a case for spinach, which might as well be applicable for meat substitutes. The impact of the product's newness on acceptance is underpinned by the optimal arousal theory (Berlyne, 1970) which assumes that stimuli that are moderately novel, surprising, or complex will be preferred over stimuli that offer too much or too little novelty. Translating this idea directly into development of products is challenging since the difference and balance between new, too new or too familiar is difficult to assess, and highly dependent on the individual (Birch & Marlin, 1982). What we do know is that each individual judges newness by using a reference product against which the new product is compared [see reviews by Michaut (2004) and Van Trijp & Van Kleef (2008)]. Thus, the degree of similarity between a reference (e.g. meat) and new product (e.g. a meat substitute) is highly relevant for an individual's perception of newness. In addition, unfamiliar foods that resemble familiar foods that are part of an individual's current diet, are more likely to be accepted (Tuorila, et al., 1998).

Besides product-related factors such as newness, personal characteristics of the consumer play a role in long-term acceptance as well. Food specific personality traits such as food neophobia (avoidance of new foods) and the opposite, a high willingness to try new foods, have been shown to have an effect (negative and positive, respectively) on new food behaviour (e.g. Tuorila, Lähteenmäki, Pohjalainen, & Lotti,

2001; Olabi, Najm, Baghdadi & Morton, 2009; Verdurme, Viaene & Gellynck, 2003). Although there are stable individual differences in the tendency to be neophobic, the exposure to novel foods can reduce food neophobia and increase the willingness to try these products (Pliner et al., 1993). Another personal factor that may play a role in long-term acceptance is variety seeking. Consumers might switch from one product to another because they are intrinsically motivated to experience variety (Van Trijp, Hoyer, & Inman, 1996). When the level of stimulation is too low, such as in the case of boredom, variety seeking is a means to increase stimulation and restore it to the individually preferred level (Berlyne, 1960). We therefore expect that certain personal food attitudes, such as food neophobia and variety seeking will have an effect on how persons hedonically respond to repeated exposure to new food stimuli such as meat substitutes.

In addition to product and person related factors, several authors have stressed that in studying food acceptance, contextual factors should be taken into account since context can alter the perception of food and beverages during consumption (e.g. Cardello, 1995; Jaeger, 2006; Meiselman,1992; Meiselman, 2000). With respect to our interest in meat substitutes as a hot meal component, one of the contextual factors, namely the meal context, is of particular importance (Elzerman, 2006). Different components of a meal can offer a level of variety, also referred to as the within-meal variety (Meiselman et al., 2000). Meals can be seen as a bundle of several combined characteristics and the interactions between different items contribute to the overall sensory experience (Fischer, 2007; Rozin & Tuorila, 1993). Probably, meals can also offer consumers a degree of variation for repeatedly consumed products. The influence of freedom and variety in meals was previously described by Zandstra, De Graaf & Van Trijp (2000) who demonstrated that this resulted in less product boredom after repeated exposure.

In summary, it has been shown that several factors both related to the product (e.g. newness and familiarity), the person (e.g. need for variety, neophobia), and contextual factors (e.g. meal context) play a role in long-term acceptance of food products. For some products, particularly new products, experience is needed before appreciation. For other products, boredom occurs after extended use. For the development of new meat substitutes, it is highly relevant to know which of these scenarios correspond with current meat substitutes on the market. Therefore, the hedonic effects of repeated exposure to meat substitutes and meat in a real life setting were investigated. We expected that over time a meat substitute would be less liked than a meat product and that a meat substitute dissimilar to meat would be less liked than a meat substitute more similar to meat. The influence of personality traits, such as food neophobia and variety seeking, and meal context on acceptance were considered as well.

6.2 METHODS

Study design

We performed a consumer study aiming for realistic conditions: a long-term in-home use test of 10 weeks, with twice-a-week consumption of selected meat substitutes or a reference meat product. The repeated exposure thus consisted of 20 exposures, which has shown to be sufficient in other studies to demonstrate boredom effects and increase validity compared to a single taste test (see Zandstra et al., 2004). Due to the labour-intensiveness, only 3 products were carefully selected for the study, as described below. The design of the study was a between-subject design: study participants (n = 89) were assigned to one of three product groups: two meat substitute groups (A and B) and one meat reference group (C). Each person was repeatedly exposed to one type of product during the study. The study was preceded by a central location test, in which several types of meat substitutes were tested separately and in different meal combinations (not described in this thesis). These included the products selected for the in-home use test. After the in-home use test we held semi-structured interviews to gain more insight in the participants' experiences with the product over time. The outcomes of these interviews are briefly discussed in the discussion.

Participants

Participants were 89 relatively highly educated Dutch-speaking residents of Wageningen, aged between 18 and 66 years (20 males; sample mean age was 35 years). Vegetarians were excluded because they are not the intended target group for new sustainable meat substitutes (Aiking et al., 2006) and because every participant had to eat a meat product in the pre-exposure central location test. Persons with specific food allergies like soy allergy were also excluded. Participants were randomly assigned to product group A, B or C, balanced for ratings for the Food Neophobia Scale, familiarity with meat substitutes (based on habitual consumption), age and sex (Table 6.1).

Products

We wanted to test whether there were differences in changes in liking over time between meat and meat substitutes that are similar and dissimilar to meat. Therefore, 2 meat substitute products and 1 meat reference product were selected by the following criteria:

a. Actual products that were commercially available
b. Same set of product form (e.g. ingredients, hamburger, cold cuts).

Ingredients were chosen since we wanted to ensure that the product was used as part of the main hot meal, which was the aim of the overall research program. We also

Table 6.1: Personal characteristics of participants

	A. Quorn group (n=30)	B. Tofu group (n=31)	C. Chicken group (n=28)
Age y (mean ± *SD*)	35 (15)	34 (16)	36 (16)
Sex (% female)	77%	81%	75%
Food neophobia scores (mean ± *SD*)	24 (5)	23 (7)	24 (7)
Variety seeking behaviour (mean ± *SD*)	46 (5)	45 (8)	44 (9)
Familiarity with meat substitutes: consumption			
never or once	40%	37%	43%
< once a week	33%	40%	36%
≥ once a week	28%	23%	21%
Chicken consumption			
< once a month	18%	35%	7%
< once a week	39%	24%	39%
≥ once a week	43%	41%	54%

Personal characteristics were not significantly different between groups.
Note that one person in the Quorn group dropped out after 7 sessions, due to boredom with the product.

wanted to offer participants the opportunity to vary the other meal components, as would happen in the real world.

c. Same set of product type (chicken vs. beef like products)

Amongst other flavours, mainly 'white' (referring to chicken) or 'brown' (referring to ground beef) types of meat substitutes were available. Due to criteria below, we selected 2 products from the 'white' range to compare with chicken fillet pieces hereafter referred to as chicken.

d. Mean initial liking scores above 50 on a 100 mm scale

The product had to be of a certain quality in order to be able to comply with an exposure of twice a week for 10 weeks.

e. Meat substitute products that varied extremely in the perceived similarity to meat.

As part of the product selection procedure we performed an exploratory study with 22 non-vegetarian consumers to test 6 different meat substitutes and chicken for their hedonic attributes (liking appearance, liking smell, acceptance, liking, intention to use), sensory attributes (smell, taste, texture) and perceived similarity to meat. Amongst these products were Quorn stir-fry pieces and lightly seasoned tofu stripes (brand SoFine). Quorn is a mycoprotein, a meat substitute derived from a fungus (McIlveen et al., 1999; Wiebe, 2004). Tofu is a vegetable protein source, made from soy bean curd (McIlveen et al., 1999). These products are hereafter referred to as Quorn and tofu. In the exploratory study, Quorn and tofu scored in similar ranges for acceptance (liking on a 100 mm scale Quorn mean 63 ± 29, tofu mean 52 ± 26) but scored very different in similarity to meat. Quorn was found to be most similar (mean

62 ± 27 on a 100 mm scale) and tofu least similar to meat (mean 26 ± 19). Twenty-two% of participants thought Quorn was a meat product while none of the participants thought this was the case for tofu. This is line with other reports (McIlveen et al., 1999; Rodger, 2001) in which Quorn has been described as meat substitute product with a meat-like texture and comparable textural complexity as chicken. Tofu is a soft and homogenous product and less similar to meat in comparison to Quorn (McIlveen et al., 1999). Thus, according to the selection criteria d and e, tofu and Quorn were selected as test products (Table 6.2). Before distribution to participants, chicken fillet pieces were pre-cooked in order to achieve a standard at home preparation procedure for all 3 products (stir-fry for 5 minutes) and because of food-safety concerns. Since the meat substitutes contained some flavouring, the chicken fillet pieces were slightly flavoured before pre-cooking as well. The products were consequently re-packaged and portioned in unlabeled bags of 150 grams.

Table 6.2: Nutritional composition of the test products

g /100 g unprepared product	Quorn*	Tofu**	Chicken***
Energy (kCal)	103	196	110
Protein	14.0	17.5	23.3
Fat	2.6	13.5	1.8
Carbohydrate	5.8	1.0	0.0

*Quorn manufacturer's data.
**SoFine manufacturer's data.
***NEVO table 2006 (NEVO, 2006).

Procedure

Twice a week, participants collected the cooled product with enclosed questionnaire from the research location. The product had to be used as a meal component within the hot meal at the same or following day according to preparation guidelines: stir frying for 5 minutes in sunflower cooking oil in a separate cooking pan. There were no limitations to the accompanying hot meal components except for the use of strong masking flavouring or very spicy sauces. The minimum amount to consume was one third of the provided amount (50 grams). In order to fix exposure across product groups, it was not allowed to eat any other meat substitutes and chicken fillet on the remaining five days of the week during the entire study period.

Questionnaires

Questionnaires were used to assess participants' hedonic product evaluations over time and to explore the role of personal factors and varying meal context.

Product questions — The hedonic product questions were filled out by the participant at home and are listed in Table 6.3. Subjects also rated the degree of hungriness (100 mm VAS scale) before consumption and whether their taste or smell was affected that day.

Meal questions — Participants reported which meal components accompanied the test product in specific categories (type of carbohydrates, vegetables and type of sauce or adding). Questions for the whole meal were comparable to the hedonic product questions listed above, namely desire to eat, liking and boredom on a 100 mm line scale. In the actual questionnaire, questions about the meal were listed before the product ratings.

Personal factors — The following personal characteristics were recorded before the start of the study: age, sex, familiarity with meat substitutes in general (recorded as the habitual consumption of meat substitutes in 7 categories: never, a single time, less than once a month, less than once a week, once or twice a week, three or four times a week, 5 times or more a week), and habitual consumption of chicken fillet. As a measure for food neophobia, the Food Neophobia Scale (FNS) with 7-point Likert scale was included (Pliner & Hobden, 1992) which assesses the tendency of people to try new foods. The questionnaire was translated into Dutch by a translation-back translation procedure by a professional agency. As a measure for variety seeking, the VARSEEK-scale was used which assesses consumer's variety seeking tendency with respect to foods in applied settings (Van Trijp, 1995). The original Dutch version of the VARSEEK was used with a 7-point Likert scale.

Table 6.3: Hedonic product questions

Desire to eat product*	How much desire do you have to eat this meat (substitute) product at this moment?	No desire at all – desire extremely On 100 mm VAS
Liking of product	How much did you like the meat (substitute) product?	Not at all liked – extremely liked On 100 mm VAS
Boredom of product	How bored are you from this meat (substitute) product?	Not at all bored – extremely bored On 100 mm VAS
Eaten Amount	How much did you eat eat of the meat (substitute) product?	Categories (less than 1/3, 1/3, ½, 2/3, more than 2/3, all),

*'Desire to eat' was filled out before eating; the other questions were rated after finishing the meal.

Data analysis

Data were analysed with SPSS 14.0 for Windows and p-values <0.05 were considered to show statistically significance.

Liking and boredom of products over time — We investigated whether there were differences between appreciation for Quorn, tofu and chicken (measures: liking, desire to eat en boredom en eaten amount) at the start of the study (session 1) and at the end of the study (session 20) by using ANOVA with Post Hoc analyses (Games-Howell). Possible differences between the product groups in smell/taste ability during the study were also checked by ANOVA. Spearman correlations were calculated for the relation between liking, desire to eat en boredom ratings. Hedonic changes over time (measures: liking, desire to eat en boredom) were further considered by calculating individual slopes using regression analyses with session (by forced entry) and hunger (by stepwise method) as independent variables. For some individuals hunger was excluded from the model. Individual slopes were subsequently compared across product groups with ANOVA.

Variety in individual responses — We visually inspected individual product liking scores over time and assigned a pattern based on individual regression coefficients: $\beta \leq -0.1$ = 'Boredom pattern'; $\beta \geq 0.1$ = 'Mere exposure pattern'; $-0.1 < \beta < 0.1$ = 'No change pattern'. Numbers of participants with different liking patterns were compared between product groups by a Chi-square test. Due to cell counts below 5, 'No change pattern' was excluded from analysis.

Influence of the meal — The difference between liking for the overall meal and liking for the product during the 20 in-home sessions was analysed by a *t*-test for each product group. Similar to analysis of the product data, influences of repeated exposure on hedonic ratings for the overall meal were analysed by repeated measures ANOVA (Greenhouse-Geisser correction applied) and calculation of individual regression coefficients. Three types of variables were assessed from the meal recordings: type of meal, number of different meals, number of switches between different meals. Meal components that accompanied the product were analysed to appoint *type of meal* based on carbohydrate source in 9 categories: rice, potato, pasta, noodles, pizza, beans, soup, salad, and other. Frequencies of the types of meals used were compared across the product groups by a Chi-square test. As an indicator of level of variety sought, for each individual *the number of different meals* was computed based on how many types of meals (categorized following the description above) were used during the in-home use period. How many times individuals changed from one type of meal to another type of meal between consecutive sessions was used to determine the *meal switches*. The numbers of different meals and meal switches were compared between product groups by ANOVA. The relation between liking of a product over time (individual regression coefficients) with the number of different meals and meal switches were investigated by Spearman correlations.

Influence of product familiarity, food neophobia and variety seeking — The influences of the personal variables food neophobia and variety seeking on hedonic product

scores over time (individual regression coefficients) were investigated by Spearman correlations. The sample was divided into subgroups high/low food neophobia and variety seeking scores based on a split at group mean level (at FNS = 24, VARSEEK = 45). We compared hedonic patterns (boredom, mere exposure, no change) across product familiarity classes and the FNS and VARSEEK subgroups by Chi-square tests. The role of product familiarity was further analysed by comparison of individual regression coefficients (liking and boredom) between product familiarity classes with ANOVA.

Main effects on product liking — To assess the relative contribution of the different factors on product appreciation, a regression model was constructed with product liking as dependent variable and the following independent variables by stepwise method: hunger, the number of different meals used, meal switches, VARSEEK, food neophobia, familiarity with meat substitutes (in 5 categories ranging from never to 3-4 times per week). Time (session number) was included in the model by forced entry.

6.3 RESULTS

Liking and boredom of products over time

At the start of the in-home use test, both meat substitutes products Quorn and tofu were significantly less liked than chicken (Table 6.4). But after the repeated exposure period, there were no significant differences anymore in liking scores between meat substitute groups (Quorn 54 ± 29, tofu 60 ± 29) and the chicken group (68 ± 26). Figure 6.1 shows that overall, liking for all 3 products decreased over time ($F(10,734) = 3.27$; $p < 0.001$). There was a significant difference in decrease in liking between product groups ($F(2,75) = 3.58$; $p < 0.04$). Similarly, boredom of the products increased significantly over time ($F(11,843) = 1.98$; $p < 0.03$). The increase in boredom ratings did not differ between product groups.

Table 6.4: Initial acceptance ratings for products (mean ± *SD*)

	Quorn (n=30)	Tofu (n=31)	Chicken (n=28)
Liking	60^{a} ± 28	68^{b} ± 21	81^{ab} ± 19
Boredom	36 ± 30	33 ± 31	25 ± 26
Desire to eat	63^{c} ± 25	66 ± 25	77^{c} ± 16

Difference in liking between product groups: $F(2,86) = 6.27$, $p < 0.004$, [a]Quorn significantly different from chicken, $p < 0.004$, [b]Tofu significantly different from chicken, $p < 0.04$.

Difference in desire to eat between product groups: $F(2,86) = 3.35$, $p < 0.05$, [c]Quorn significantly different from chicken, $p < 0.03$.

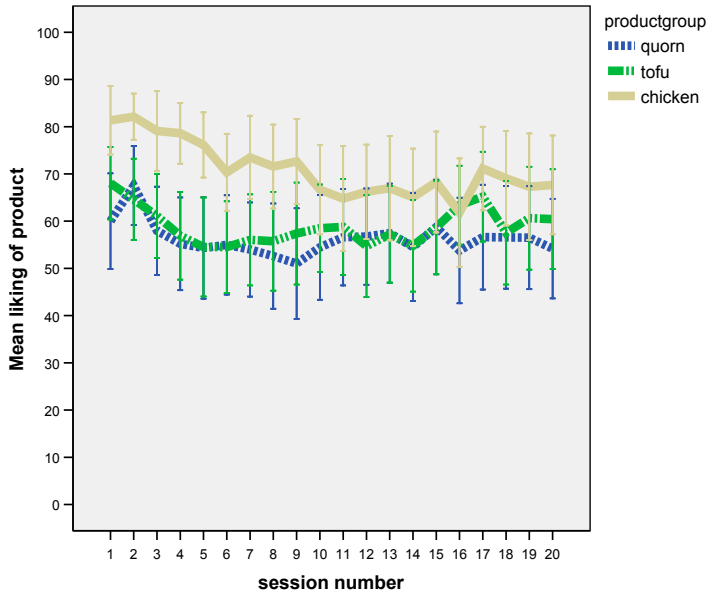

Figure 6.1: Product liking over time with repeated exposure to either Quorn, tofu or chicken (mean ± 2*SE*)

On average participants ate 2/3 (100 g) of the provided product during the study. Over time, the eaten amount of product slightly decreased, although not statistically significant ($F(11,679) = 1.68$; $p = 0.075$). The amount eaten of the products did not differ between the product groups.

All ratings for liking, boredom and desire to eat were strongly related to each other (r range 0.65 - 0.80), but ratings for liking were consistently higher than desire to eat ratings. Smell/taste ability, which could have influenced hedonic scores, did not differ between product groups during the study.

The relative change over time was considered by individual slopes of hedonic scores (Table 6.5). The relative decrease in liking was highest for chicken, although differences between groups were not statistically significant ($F(2,86) = 2.53$; $p = 0.085$). A reversed effect was found for boredom ratings. Thus, the chicken group showed the highest relative increase in boredom, while meat substitute groups were less bored over time. In addition, the product tofu, which is least similar to meat, showed overall a minor decrease in liking.

Variety in individual responses

The error bars in Figure 6.1 and ranges in individual regression coefficients (Table 6.5) show that there were significant differences between hedonic responses of individuals within product groups. Closer examination of the individual responses revealed that within each product group, some of the typical responses as shown in Figure 6.2 were observed. While some participants liked the product better over time, called 'Mere exposure pattern', others showed a reversed reaction and got bored, called 'Boredom pattern'. There were also a few persons who did not vary their scores for the product, called 'No change pattern'. The number of persons with a certain response differed between the groups. Table 6.6 illustrates that the majority of the individuals who ate tofu showed a mere exposure pattern in contrast to individuals from the chicken group in which boredom was the dominant pattern.

Table 6.5: Mean individual regression coefficients (β) for product liking, boredom, and desire to eat over time

	Quorn (n=30)		Tofu (n=31)		Chicken (n=28)	
	β (*SE*)	Range	β (*SE*)	Range	β (*SE*)	Range
Liking	-0.22 (0.22)	-2.5 – 2.3	-0.07 (0.23)	-3.4 – 2.9	-0.78 (0.24)	-3.8 – 1.2
Boredom	0.33 (0.31)	-2.7 – 5.3	-0.14 (0.25)	-2.5 – 3.1	0.64 (0.29)	-1.4 – 4.5
Desire to eat	-0.44 (0.20)	-2.8 – 2.2	-0.49 (0.24)	-3.8 – 2.8	-0.69 (0.28)	-4.5 – 2.0

SE = Standard Error of the mean.
A negative β value indicates a decrease in ratings over time.

Table 6.6: Number of participants with a boredom pattern, no change or mere exposure pattern

	Quorn	Tofu	Chicken
Boredom pattern: n (%)	16 (54%)	13 (42%)	19 (68%)
No change pattern: n (%)	3 (10%)	1 (3%)	4 (14%)
Mere exposure pattern: n (%)	11 (37%)	17 (55%)	5 (18%)

Frequencies of boredom patterns compared to mere exposure patterns across groups were significantly different: $X^2(2,79) = 7.10$; $p < 0.03$.

Influence of the meal

Within each product group, the overall meal was liked better than the test product [scores on liking scales - Quorn: meal 70 ± 21, product 56 ± 28, $t(597,598) = 16.85$, $p < 0.001$; tofu: meal 74 ± 16, product 59 ± 27, $t(613,614) = 16.01$, $p < 0.001$; chicken: meal 75 ± 18, product 71 ± 25, $t(552,553) = 4.71$, $p < 0.001$]. In contrast with the product results, participants were not bored over time with the entire meal (liking $F(2,185) = 1.13$, $p = 0.33$; boredom $F(14,1016) = 1.10$, $p = 0.36$ and desire to eat $F(14,1065) = 1.49$, $p = 0.11$) and there were no significant differences between product groups. This was

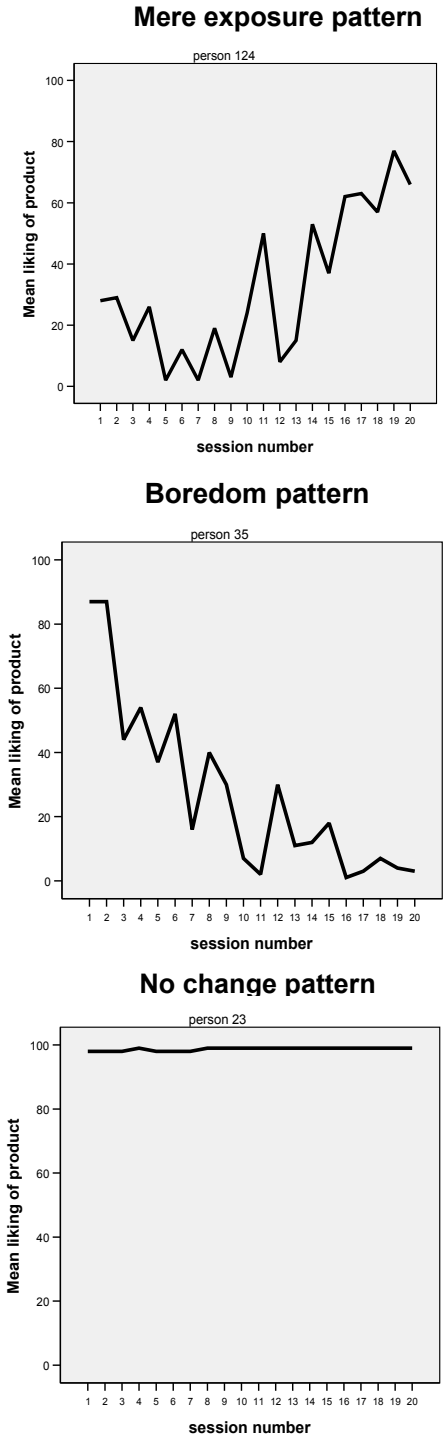

Figure 6.2: Different individual responses on repeated exposure of products
The figures illustrate 3 typical individual response patterns: mere exposure, boredom and no systematic changes.

confirmed by the mean individual regression coefficients of meal liking over time that were noticeably smaller than coefficients for liking of product over time [Quorn β = 0.07 (SE = 0.13), tofu β = -0.03 (SE = 0.69), chicken β = -0.24 (*SE* = 0.77)].

We analysed the meal data (1765 recorded freely chosen meals) by looking at three variables: 1. the type of meal (type of main carbohydrate component), 2. the number of different meals used during the study period, 3. meal switches (how many times participants switched type of meal between consecutive test sessions). The types of meals participants used to combine with the product were not significantly different between product groups. Most of the time, the product was applied to a rice meal (Quorn 39%, tofu 35%, chicken 33%). The second used meal type was a potato dish (Quorn 27%, tofu 26%, chicken 30%), followed by a pasta combination (Quorn 15%, tofu 19%, chicken 18%). The number of different meals used by participants during the study period varied from 1 type of meal (rice dish) to 8 different types of meals (rice, potato, pasta, egg noodle, pizza, beans, soup, salad). There was no significant difference between the number of different meals between the product groups. However, we found a significant correlation of 0.3 between individual regression coefficients of product liking and the number of different meals used ($p < 0.02$). Thus, participants who were relatively bored used more types of meals during the study.

Concerning the switches between types of meals, we found that participants in the chicken group switched more than those in meat substitute groups (borderline significance, $F(2,86) = 2.95$; $p = 0.058$). Overall, the number of meals used and the individual regression coefficients for product liking were inversely related ($r = 0.4$; $p < 0.001$). Thus, participants who were relatively bored switched more during the study.

Influence of product familiarity, food neophobia and variety seeking

All participants in this study were relatively food neophilic and high variety seekers: food neophobia scores of participants ranged from 12 to 39, and VARSEEK from 26 to 56 (total scores on 7 point-scales). Initially, we anticipated that higher food neophobia scores would relate to less boredom over time and a higher occurrence of mere exposure patterns and reversed outcomes for higher variety seeking scores and being more familiar with meat substitutes. However, we did not find statistical significant associations with hedonic scores or meal choice behaviour with these personal characteristics alone.

Main effects on product liking

The sections above described the effect of different factors on product liking and boredom over time separately. The question arises which of these product-, personal- and contextual factors have the most effect on overall liking ratings. Table 6.7 shows that in this study the type of product was the most important contributor to liking

scores. Besides time and hunger, the personal factors familiarity with meat substitutes and contextual factor number of different meals used had the most dominant effect on product liking. Thus, being more familiar with meat substitutes was associated with higher liking scores for the product, while using more types of meals was associated with lower liking scores. Variety seeking, food neophobia, and changes in meals were excluded by the model.

Table 6.7: Predictors of product liking

	Regression coefficient	*SE*	*t*	*p*-value
Product	6.6	0.7	8.8	< 0.001
Different meals used	-3.6	0.4	-8.7	< 0.001
Familiarity with meat substitutes	2.4	0.4	5.9	< 0.001
Hunger	0.4	0.03	13.7	< 0.001
Time	-0.3	0.1	-2.9	< 0.004
Constant	33.5	3.6	9.4	< 0.001

Variance explained by the model is 45% (R^2 = 0.45).

6.4 DISCUSSION

The effect of repeated exposure on acceptance of meat substitutes

The outcomes of this study were opposite to our initial hypotheses. After 20 exposures, both meat substitutes (Quorn - more similar to meat, tofu - less similar than meat) and a meat reference (chicken) were approximately equally liked. Liking for the meat reference product chicken decreased more over time than liking for meat substitutes. In addition, the meat substitute least similar to meat (tofu) was overall least boring over time. Particularly in the tofu group, more than half of the individuals actually showed a mere exposure pattern and thus liked the product better over time. It must be noted that, despite the higher boredom scores, the meat reference chicken was on average still the most liked product during 20 sessions, which agrees with the current market situation of meat substitutes.

The influence of product characteristics on changes in liking

Several product characteristics of the selected meat and meat substitutes need to be considered in interpretation of the results. Certain product properties related to the arousal level might play a role in acceptance after repeated exposure: intensity, complexity and novelty (Berlyne, 1970), which have been investigated in previous studies, usually focussing on one of these perceived properties (Chung & Vickers, 2007; Lévy, MacRae, & Köster, 2006; Porcherot & Issanchou, 1998; Sulmont-Rossé,

Chabanet, Issanchou, & Köster, 2008; Vickers & Holton, 1998; Weijzen, Zandstra, Alfieri, & De Graaf, 2008; Zandstra et al., 2004). The major aim of our study was to find out how repeated exposure to meat substitutes, which are products that are relatively new and less accepted compared to meat, would affect liking. We did not consistently vary and assess perceived intensity, complexity, and novelty, but chose two actual meat substitute products that varied in their resemblance to meat. We think that ratings for 'similarity to meat' fits better with consumers' own language (Elzerman, 2006; Levy et al., 2006). A comparable type of rating, namely resemblance to familiar foods, was used earlier by Tuorila et al. (1994). Similarity or resemblance might be seen as a specific feature of newness, namely the deviation or agreement with a reference product (as reviewed by Michaut, 2004), in this case meat. The results showed that the meat substitute tofu, which is dissimilar to meat, was liked better by the majority of the tofu participants after a period of repeated use. This is in line with the mere exposure effect which is relevant for stimuli that are moderately novel, unfamiliar, or unusual (Zajonc, 1968; Birch & Marlin, 1982). Recent studies have again confirmed this effect with relatively unfamiliar foods or drinks (Bingham et al., 2005; Sulmont-Rossé et al., 2008). This would imply the occurrence of a cognitive effect and that repeated exposure is a way to decrease consumer uncertainty on unfamiliar foods, which is relevant for meat substitutes (Bingham et al., 2005; Hoek et al., submitted for publication, Chapter 3b; Stang, 1975; Sulmont-Rossé et al., 2008).

'Similarity to meat', in terms of having a meat-like texture or flavour, might also refer to a certain degree of complexity. How perceived complexity relates to the study results is unclear and against expectations. We initially expected that meat substitutes with a more complex structure, like Quorn, would result in less boredom over time compared to a more homogeneous product like tofu. Instead, we found the opposite. Lévy et al. (2006) state that mere exposure is only to occur for products that are more complex than the initial individual optimum. This would imply that tofu is overall perceived as more complex than Quorn. However, it is more likely that the selected products varied along different properties and therefore the results cannot be deduced at the level of complexity alone (Lévy et al., 2006).

The vast decrease in liking of chicken needs to be seen in the light of other reports that showed that highly liked foods display a larger drop in liking, compared to moderately like foods (Hetherington, Pirie, & Nabb, 2002; Hetherington, Bell, & Rolls, 2000; Chung & Vickers, 2007). After all, a product that is very acceptable at the start may be more boring than a product that is initially relatively unacceptable because liking can only get less under these study conditions (Köster, 2003; Moskowitz[a], 2000). As shown in the real market place, the results of this study thus need to be interpreted as 'meat substitutes may be liked better by some persons over time' instead of 'chicken is boring over time'.

The influence of meals on product acceptance over time

This study demonstrates that the meal context plays an important role in acceptance of meat and meat substitutes as hot meal components and illustrates that meal context is relevant for studies on long-term acceptance. Although the appreciation for both types of meat substitute products was generally less than for chicken, meals containing these different products were almost equally liked. We also found that overall meals containing these products were not boring over time. It thus seems that other self-selected meal components were able to lift the final judgement for the meal, despite a less liked item in it. These results support the importance to test food products that are usually eaten in a meal, such as meat substitutes, in a meal setting (Elzerman, 2006; King, Meiselman, Hottenstein, Work, & Cronk, 2007). It is currently unclear how and to what degree liking or boredom of a single product is influencing the appreciation for the entire meal. Although it is recognized that meal acceptability and appropriateness of foods have an important influence on what is selected, there is still limited data on the combination of foods available (Marshall & Bell, 2003). Liking for a combination of food items is obviously not the arithmetic average of the liking for the separate components, and there are differences across meal components and types of meals (e.g. Eindhoven and Peryam, 1959; King, Weber, Meiselman, & Lv, 2004; King et al., 2007; Köster, 2003; Meiselman, 2000; Moskowitz[b], 2000).

To our knowledge, there are only a few studies that took the meal context into account during repeated exposure studies (Bingham et al., 2005; Zandstra et al., 2000). Bingham et al. (2005) unfortunately did not describe the impact of the other meal components in detail, while Zandstra et al. (2000) introduced meal variety as a controlled factor in the intervention. The latter study demonstrated that freedom and variety in meals resulted in less boredom. It must be noted that these study conditions differed from our study where all participants were allowed to vary meal components. We namely found the opposite effect: individuals that were more bored sought more variety in meals, either by number of different meals during the study period, or changing meals in consecutive test days. It would be interesting to further investigate boredom at the level of the meal and how different meal components interact to a certain level of variety and complexity which alleviates boredom. Moreover, this should be regarded in the context of actual consumer choice behaviour; how consumers choose and switch among different meals to compensate for boredom with one of the meal components.

The influence of personal factors on product acceptance over time

At the start of the study we hypothesized that personal factors play a role in long-term acceptance of meat substitutes: food neophobics would be less susceptible to boredom after repeated exposure while variety seekers would be bored more easily.

We did not found such an effect: the range in individual responses (both boredom and mere exposure types) following repeated exposure to meat substitutes could not be explained by these personal characteristics. It is firstly important to note that our sample was relatively food neophilic and high variety seeking, e.g. the mean FNS score of a representative Finnish sample was 34 (Tuorila et al., 2001) compared to the mean FNS of 24 of our sample. However, several studies did not found an effect of general personal food attitudes on the choice or liking of specific products (e.g. Chung & Vickers, 2007; Jaeger, Rossiter, Wismer, & Harker, 2003; Hoek et al., submitted for publication, Chapter 3b; Lähnteenmäki & van Trijp; 1995). Familiarity with the product under investigation might be of more importance on product acceptance, since we found that the person's familiarity with meat substitutes was related to higher liking scores. These results are in line with a previous consumer survey (Hoek et al., submitted for publication, Chapter 3b).

It is obviously important to consider individual responses in repeated consumption studies (see also studies of Chung & Vickers, 2007; Zandstra et al., 2004). Persons differ in how they respond and we found a wide range of individual responses for each of the products in our study; both boredom (decrease in liking) and mere exposure (increase in liking) patterns. Why some persons got bored and others got to like the test products better is still unclear. Using meat and meat substitutes as stimuli, certain other personal characteristics might well play a role in this. Several studies have reported that positive attitudes towards nutrition and health, and ecological aspects, are of influence on the consumption of these type of products, even so in non- or partly vegetarian consumers (Hoek et al., 2004; Janda & Trocchia, 2001; Lea & Worsley, 2001; Santos & Booth, 1996; Sadler, 2004). Unfortunately, we did not assess other personal variables than familiarity with meat substitutes, food neophobia and variety seeking, and were unable to verify the influence of certain personal attitudes or beliefs on the dynamics of liking of meat substitutes.

Further methodological considerations

A strong point of our study is the performance under fairly realistic conditions. Using manipulated foods in artificial situations is a way to study factors on food intake under controlled circumstances, but is less related to ultimate product acceptance by the consumer (Meiselman, 1992). In this study, we therefore used commercially available products, and persons prepared and used the products at home in a dinner setting. Opposite to the study of Zandstra et al. (2000), in which participants of the variety group could vary three meat sauces as part of their meals, our study let consumers freely decide on any meal component accompanying the test product. However, inevitably there were some study guidelines that were limiting normal cooking and eating behaviour to some extent: restrictions in use of hot spicy sauces for instance

and the use of *pre*-fried chicken pieces. This was also reported back in the evaluative interviews with study participants. We have to keep in mind that this type of repeated in-home testing is still a forced exposure that deviates from actual consumer behaviour.

In order to achieve a sustained liking of new products, such as new sustainable meat substitutes, ideally one would focus in the early phase of food product development on certain attributes that ascertain a long-term acceptance by consumers (Hansen, 2005; Moskowitz[a], 2000). Unfortunately, this is not so simple, if even possible. Firstly, boredom seems to be complex and vague both for researchers and consumers (Köster, 2003; Moskowitz[a], 2000). With respect to researchers, there is not a general definition for the concept boredom or monotony and consequently different measures have been used in studies, looking at time to recovery or decreases/increases via ratings or observed behaviour for: liking, boredom, pleasantness, desire-to-eat, product intake, probability of choosing a food, and interest in the product (Chung & Vickers, 2007; Meiselman, De Graaf, & Lesher, 2000; Moskowitz[a], 2000; Zandstra et al., 2004). More work needs to be done to unravel the underlying mechanism(s) of boredom, either related to a neural/physiological or a cognitive response (Zandstra et al., 2004), in order to make reliable predictions on long-term product acceptance. With respect to consumer experiences: the exact measures (boredom, liking) used in questionnaires are in contrast to the vague feelings consumers have about 'getting bored' (Moskowitz[a], 2000). Comments of study participants in interviews we held after the in-home use test are in line with remarks of Moskowitz[a] (2000): consumers could not define boredom in detail except for describing a feeling or situation: 'After a while I got tired with it', let alone they were able to describe certain product characteristics or factors related to boredom. We suggest that further research is performed in order to combine actual consumer perceptions and factual measures used for long-term acceptance studies in the future. Secondly, in order to develop products that are not boring over time, product developers need to know which product characteristics are responsible (Moskowitz[a], 2000). In research, food products have been tested with varying degrees of novelty, complexity and intensity to evaluate the effects on acceptance (Chung & Vickers, 2007; Lévy et al., 2006; Porcherot & Issanchou, 1998; Sulmont-Rossé et al., 2008; Vickers & Holton, 1998; Weijzen et al., 2008; Zandstra et al., 2004). The key of success for products lies in the optimal arousal level of a stimulus, which is a combination of all three factors (Berlyne, 1970). However, the search for optimal arousal and right balance of these three factors has shown to be very challenging due to individual differences in optimal arousal levels and the lack of operational measures to assess this (Pliner & Melo, 1997). The exact sensory properties driving long-term acceptance are currently not known yet (Weijzen et al., 2008). In practice this means that in the product development process, evaluative repeated

home-use testing with a real product(concept) is still necessary and the best approach, which requires additional costs and time (Moskowitz[a], 2000; Zandstra et al., 2004).

Conclusions and implications for new meat substitutes

The greatest challenge for environmentally-friendly meat substitutes, which substantially need to replace meat in the diet, seems to be the initial lower appreciation and unfamiliarity of meat substitutes compared to meat. This is in line with preceding studies (Elzerman, 2006; Hoek, 2006; Hoek et al., submitted for publication, Chapter 3b). The current low frequency of use of meat substitutes is probably not caused by boredom with these products over time. The results showed that, at least for a part of consumers, repeated use might help to increase liking for meat substitutes that are even dissimilar to meat. However, due to low initial liking scores compared to familiar meat products (such as chicken), in real life a lot of non-vegetarian consumers never get to the point to use meat substitutes repeatedly. In order to improve long-term acceptance of meat substitutes, we suggest it is now more important to focus on increasing the willingness to try and to establish positive *initial* product experiences. Besides improving the quality of single products, the meal context needs to be considered in further development of meat substitutes as well.

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Chapter 7

General discussion

GENERAL DISCUSSION

This thesis investigated which factors play a role in consumer acceptance of meat substitutes to decrease the consumption of meat. The reason for this investigation is the need to reduce the environmental impact caused by the production of meat for human consumption. One potential way to achieve this is, is by offering consumers a new plant-based substitute product, called Novel Protein Foods. The overall research program PROFETAS, of which the research described in this thesis belonged to, investigated this option. Before the actual development of Novel Protein Foods, consumer needs, perceptions and experiences need to be explored to guide the future product development of Novel Protein Foods. A multidisciplinary approach was used in order to highlight the different factors in consumer acceptance of meat substitutes. In this chapter, the main findings are summarized (section 7.1. and Table 7.1) and the implications, methodological considerations and future research areas are discussed (sections 7.2, 7.3, and 7.4).

7.1 MAIN FINDINGS

Chapter 2 looked *back in time and considered the economical/social context* in the appearance and replacement by different food substitutes (sugar substitutes, fat substitutes, margarine, texturized vegetable protein (TVP), and breakfast drinks). Obviously, a number of dynamic and interacting factors plays a role in substitution. It seems that both technological advances and governmental policies can positively influence the development of food substitutes by creating favourable preconditions. Technological advances contributed to new opportunities to develop some food substitutes of high product quality and to make continuous product improvements. Governmental policies could stimulate an increased level of know-how, while food laws directly influenced market entry. However, the essential factor for a high degree of replacement by a food substitute was consumer acceptance. Successful food substitutes were in line with consumer trends and needs (like health for sugar substitutes, convenience for breakfast drinks) and offered specific consumer benefits. Since food substitutes need to replace existing products, a high degree of similarity to the reference product is apparently important, which is challenging for complete products (as illustrated by the failure of TVP). Substitution is moreover a matter of time, needed for both product improvements and for gradual entry in changing eating patterns.

Chapter 3 described two surveys on *consumer characteristics, motives, and attitudes and beliefs* towards meat substitutes. By comparing different acceptance levels, the drivers and barriers to use meat substitutes were identified. Obviously, vegetarians had certain ideological motives that drive their avoidance of meat towards meat substitutes, while this was not the case with non-users or light/medium-users of meat substitutes. These consumers were mainly interested in the sensory appeal and familiarity of foods. The personal trait food neophobia, the tendency to avoid new foods, was an important barrier for first trial of meat substitutes. Besides these general person-related factors on food choice, the attitudes and beliefs towards the products specifically determined consumer acceptance. An overall negative attitude towards meat substitutes was related to a lower acceptance. The meat substitute products scored particularly lower than meat on sensory attractiveness and familiarity, which were in fact the important aspects to meat consumers. In addition, the less consumers were using meat substitutes, the more they wanted these products to be similar to meat.

In *Chapter 4,* the *identification of products* was the focus of research. How consumers perceived and categorized meat products, meat substitutes and radically new concepts of Novel Protein Foods was investigated. The study demonstrated how similarity to meat is essential to be grouped in a meat category and to be seen as alternatives to

meat. The categorization of products was influenced by the deep-rooted taxonomic classification of meat, so by type of animal flesh: pork, beef, chicken, etc. Meat substitutes were therefore grouped separately from non-processed meat products. However, meat substitutes were perceived to be more similar to processed meat products and were jointly grouped in categories such as 'pieces' and 'sausages'. This is related to a similarity in appearance, but also refers to a shared application in certain meals. In contrast, new concepts that were radically different from meat (e.g. appearance like stuffed vegetables) were regarded as a completely different food category and were called 'appetizers' or 'side dishes'.

The survey indicated that even heavy-users of meat substitutes hold negative beliefs on the satiating properties of current meat substitutes. This obviously needed more attention. In *Chapter 5* the impact of the key component in satiety, namely the relative protein content, on *the product experience satiety* was investigated in more detail. A product inventory showed that current meat substitutes have generally a lower protein content compared to meat products. A consumption study with commercially available meat and meat substitutes that varied in protein content, confirmed the effect of protein level on perceived satiety: meat substitutes with a low protein content were less satiating. Noticeably, meat substitutes that had a high protein content were able to induce higher satiety feelings than the meat reference products.

In *Chapter 6* the dynamics of liking for three *products over time* was investigated. Meat substitutes dissimilar to meat (tofu) and more similar to meat (Quorn) were tested against a meat reference (chicken). The meat reference was initially liked better, but the meat substitutes and meat were equally liked after twenty exposures in ten weeks. Although on average all products decreased in liking, it was found that there were different individual responses; both boredom and increased liking patterns were observed. It was striking that there were significantly more individuals that liked the meat substitute dissimilar to meat, tofu, better over time. This is in line with mere exposure effects implicating that unfamiliar products are liked better after repeated use. The study also showed the importance of the meal in total acceptance over time: liking scores for the complete meal were stable and able to lift the relatively lower appreciation for meat substitutes separately. In addition, participants that were more bored used more different types of meals, most likely to introduce a source of variety and to alleviate boredom.

In summary, current meat consumers basically do not have an explicit need for environmentally sustainable meat substitutes. This is accompanied by considerable barriers to use meat substitutes: food neophobia, the unfamiliarity of these relatively new products, and a lesser perceived product quality than meat. Meat consumption is anchored in our culinary culture which influences the perception of other products like new meat substitutes. The option to use meat substitutes to replace meat on the

plate is accompanied by some specific challenges; it includes a direct comparison and competition with meat. For meat consumers, the balance between current meat substitutes and meat is now clearly in favour of meat. Meat has a higher perceived product quality because it matches with consumer needs, such as the sensory qualities and a high degree of familiarity.

The results are in line with the general barriers listed by Rand & Sheth (1989) for consumers to adopt innovations: a resistance due to insufficient added value (value barrier), incompatibility with current usage behaviours (usage barriers) and traditions (tradition barrier), as well as perceived risks associated with the adoption of the new product (risk barrier), and prejudices in terms of product image (image barriers). If we put this against the factors in acceptance of current meat substitutes, it is clear that these barriers are still present, in particularly this research illustrated the value barrier, tradition and image barrier. These barriers thus need to be lowered for future Novel Protein Foods.

Based on the research performed in this thesis, it can be said that if Novel Protein Foods are to substantially replace meat in the diet, these products have to offer a comparable overall product quality and certain benefits to consumers. At the present time, it seems too early to introduce products that are radically new. A certain degree of similarity to meat is preferred in terms of sensory characteristics, satiating properties, and overall appearance in order to be recognized and applied in a similar way. In this respect, it is easier to achieve replacement of processed meat products. The meal context also needs to be taken into account, since this influences liking of the separate products and may introduce some variety for repeated use. Substitution obviously takes time and is a gradual process. Time is therefore also an important factor in consumer acceptance of meat substitutes; for losing some of its unfamiliarity and to enter existing meal patterns, but also for product improvements made possible by new technologies. Overall, consumer acceptance of meat substitutes and replacement of meat depends on an interplay between factors relating to the person, product, and environment, and the right match between all aspects (Table 7.1).

7.2 THE IMPLICATIONS AND LIMITATIONS OF THE APPROACH AND FUTURE RESEARCH AREAS

The methodological considerations on the individual studies are described in each chapter. This section describes the implications of the overall approach to study the factors in consumer acceptance of meat substitutes to replace meat.

Table 7.1: Summary of the main findings on factors in consumer acceptance of meat substitutes (ms)

Chapter	Topic	Main disciplines	Product factors	Person factors	Environment factors
2	Food substitutes over time	History / sociology	*substitute is a product* (-) more challenges for product substitutes than ingredients or meal substitutes	*fits consumer needs* (+++) substitute needs to deliver desired benefits or have added value compared to the reference product	*time* (++) many years needed for development and consumer acceptance
			product quality (++) sensory quality needs to be comparable to the reference product overall high product quality with added value to consumers needed		*policy measures* (+) compliance with regulations is essential, know-how of technology can be increased by government support
					technology advances (+) offers new opportunities fo product development and product r improvements
3	Consumer motives	Consumer research Psychology	*ms unfamiliar* (--) unfamiliarity results in a lower acceptance of ms	*food neophobia* (--) avoidance of new foods is a large barrier for first trial of ms	*country with more developed market* (+) consumers living in the UK
			overall more negative attitudes and beliefs towards ms than towards meat (--) particularly the sensory appeal plays a role	*high interest in sensory appeal and familiarity in foods* (-) these general food choice motives are not fulfilled by ms	
			ms similar to meat (+) current meat consumers prefer a meat-like product	*young and highly educated* (-) personal characteristics of consumers	
4	Product identification	Consumer research Psychology	*ms have a meat-like appearance* (+) this is possible when reference products are processed meats		
			ms have same application in meals as meat (+) similarity to meat is reinforced by reference to a similar application		
5	Product experience satiety	Nutrition Food Technology	*ms have a high protein content* (+) results in higher feelings of satiety		

Chapter	Topic	Main disciplines	Product factors	Person factors	Environment factors
6	Repeated consumption	Sensory science Nutrition	*ms dissimilar to meat* (+) more consumers who like these better over time compared to a product similar to meat		*exposure over time* (+) increased acceptance of ms by some consumers
			used with different meals components (+) variation alleviates boredom		

The table shows the different factors in consumer acceptance split up for person, product and environmental factors. In bold the main findings, and right below a short explanation.
A '+' means a positive influence on acceptance and '-' a negative influence on consumer acceptance of meat substitutes.
The column 'main disciplines' refers to the main scientific disciplines applied in the research for that chapter.
The context directly surrounding the product, the meal context, has been put at the factor 'product' for clarification.

The multidisciplinary approach

The research program PROFETAS started with a complex research problem: it dealt with a push for an environmentally friendly substitute that needs to replace a highly-liked food product, meat, by current meat consumers. In order to investigate this multifaceted matter, a multidisciplinary approach was chosen that would capture different aspects in consumer acceptance of meat substitutes. The studies performed in this thesis were aimed at incorporating the role of the product, the person, and the environment, and went from assessing consumer motives to repeated consumption over time (see Table 7.1) The consequence of such an approach is that one is directly confronted with different scientific disciplines dealing with food acceptance (Becker, 2005; Jaeger, 2006; Köster, 2009; Mela, 1999). Investigating the person mainly requires psychology and consumer research, investigating the product uses sensory, nutrition and food technology research, while the environmental context is generally more on the social sciences side (see Table 7.1). This thesis represented the use of these different scientific disciplines in exploring the different factors in replacement of meat by meat substitutes. A number of aspects were considered in different types of studies (e.g. sensory appeal in Chapter 2 and 6, satiety aspects in Chapter 2 and 5) so that results were reinforced or put in perspective. For example, by doing consecutive studies it was shown that meat substitutes dissimilar to meat are *initially* less liked (e.g. Chapter 3), but after repeated use the product was liked better by more individuals than a meat-like meat substitute (Chapter 6). An advantage is that hereby, without limiting to a certain discipline (e.g. not exclusively using attitudinal measures or exclusively using sensory research), it was possible to identify different relevant issues for replacement of meat by meat substitutes, and which aspects need further attention.

However, the consequence of the multidisciplinary approach used here for exploration of relevant factors, is that mainly descriptive studies were performed. Additional studies should use experimental designs with interventions on the product, person or environment, which are suggested in the next section. Köster (2009) argued that most researchers in the field are already a long time convinced of the necessity of interdisciplinary research but that it is hardly put in practice. This thesis tried to make a first step in this direction by using different disciplines in different types of studies, centred on the central theme of consumer acceptance of meat substitutes. It is important to use multidisciplinary approaches more often in food acceptance research, for instance by cooperation of different scientists and research centres as was performed in the PROFETAS program. The current system of research funding and scientific publication criteria should change accordingly to facilitate these approaches in future research.

Identified factors in consumer acceptance: limitations and future research areas

A number of important factors in consumer acceptance of meat substitutes were highlighted but other issues need to be investigated still or need further in-depth analysis. These are listed one by one, although they are related and preferably should not be considered in isolation.

Similarity to the reference product

The degree of similarity or dissimilarity to meat as perceived by consumers, both in appearance, sensory properties and physiological properties (satiety), seems to be a crucial element for new meat substitutes such as Novel Protein Foods (Chapter 2, 3, 4, 5, 6). This was now measured by overall product perceptions of consumers and unfortunately cannot be broken down into concrete attributes due to the study designs used. It would be very useful for product development of Novel Protein Foods to know which attributes are critical in determining the perceived similarity to meat. With respect to the sensory attributes involved, sensory studies were undertaken by another PhD project. By the use of Quantitative Descriptive Analysis and relating the descriptive data to sensory consumer data, the product properties that are relevant for Novel Protein Foods can be identified (Elzerman, 2006). A methodology that makes use of consumer perceptions on a more abstract level is repertory grid (e.g. Russell & Cox, 2004; Thomson & McEwan, 1988; and reviews of Tuorila & Monteleone, 2009; Van Kleef, Van Trijp, & Luning, 2005). Subjects are repeatedly confronted with three products (in this case these could be meat and meat substitutes) and asked to indicate which two are similar and different from the third. The attributes that are perceived to be different between products can subsequently be assessed by analysis. Constructing spatial representations by multidimensional scaling can also be a useful

approach. In these representations products are viewed as points in space, varying in a number of continuous dimensions. Similarity to meat has a link with the concept of newness, because it deals with comparison of a new product (meat substitute) to a known reference product (meat) (e.g. Michaut, 2004; Van Trijp & Van Kleef, 2008). To what extent similarity and newness are similar constructs and how this affects perceived similarity to meat and meat substitutes needs to be determined still. The role of product newness is further discussed in section 7.3.

The role of expectations versus experiences

In the survey described in Chapter 3, the attitudes and beliefs towards meat substitutes were assessed. It illustrated how consumers, who had never used these products, did have certain negative expectations about them. It is relevant to study the effect of expectations because they play an important role in food consumption and choice by influencing the perception of a product (even before tasting) and the experience after tasting (including satiety). When expectations are confirmed this usually results in satisfaction and more likely a repeated product use. A disconfirmation of expectations can also cause satisfaction, but only when a positive disconfirmation occurs (e.g. meat substitutes taste better than initially thought). If negative disconfirmation takes place (e.g. meat substitutes taste worse than initially thought), it will cause product rejection. The result of confirmation or disconfirmation will in turn affect the choice and next experience with these products, by raising or lowering consumer's expectations (e.g. Brunstrom, Shakeshaft, & Scott-Samuel, 2008; Cardello, 1995; Deliza & Macfie, 1996; Issanchou, 1996; Grunert, Bredahl, & Brunsø, 2004; Schifferstein, Kole, & Mojet, 1999). In future studies, it would be interesting to investigate which expectations consumers have about meat and meat substitutes, how these were formed, and how this affects liking and choice. Furthermore, how these expectations be modulated and to what degree expectations about *current* meat substitutes influence expectations about *future* Novel Protein Foods is also important to consider.

Trade-offs and relative importance of product attributes

In the process of choosing a product, such as meat or meat substitutes, these products are compared and subsequently evaluated on certain consumer-relevant quality criteria. In the consumer survey (Chapter 3), consumer attitudes and beliefs to several aspects of both meat and meat substitutes were investigated: health, sensory appeal, natural content, ethical aspects, convenience and so on. It was found that current meat consumers, the non-users of meat substitutes, were more positive about all aspects of meat (except for weight and ethical aspects) which obviously made the choice for meat easy. However, the process of evaluation is probably more complex than this. These different product aspects might differ in importance to consumers, and

consumers are likely to make a trade-off between different attributes and benefits, such as price against animal welfare, taste against environmentally friendliness, etc. (e.g. Grunert et al., 2004; Hu, Hünnemeyer, Veeman, Adamowicz, & Srivastava, 2004). This thesis does not provide insight on which trade-offs are being made, what the relative importance of each of the attributes is, and how this affects the choice for meat or meat substitutes. Suggestions to pursue this in future research include experimental auctions in which participants face real trade-offs between money and different food qualities or conjoint choice experiments which show the relative importance of product attributes (e.g. Cardello, Schutz, & Lesher, 2007; Cox, Evans, & Lease, 2008; Jaeger et al., 2004).

The role of context

Contextual influences can be structured in simultaneous factors and temporal factors. Simultaneous factor refers to contextual factors physically present during the reference event, like the meal or people, while temporal factors refer to past or anticipated future events (Rozin & Tuorila, 1993). Only some of the many contextual factors that might play a role in consumer acceptance of meat substitutes were considered in this thesis. The influence of the overall economic/social environment was described in Chapter 2, and time and the role of the meal were taken into account in the repeated exposure study (Chapter 6). The context should get more attention in food acceptance research (Meiselman, 1992; Meiselman, 2000), and it seems this is of particular importance in studying the acceptance of food substitutes, such as meat substitutes (Elzerman, 2006). Ratneswar & Shocker (1991) described that substitution is highly dependent on the usage situation (e.g. at lunch or at dinner). In addition, the situational context, where (e.g. restaurant, home, work) and with whom (e.g. alone, friends, colleagues) might play a role in acceptance of meat substitutes. Rousset, Schlich, Chatonnier, Barthomeuf, & Droit-Volet (2008) for instance described how happy emotional expressions of others increased the desire to eat unfamiliar and familiar meat products. King, Meiselman, Hottenstein, Work, & Cronk (2007) varied four contextual influences in one study: meal, social, environment and choice, and thereby were able to demonstrate the relative importance and effect on consumer acceptance of certain foods and beverages (e.g. lasagne and iced tea). A similar set-up would be needed for meat substitutes, in which the substitute and the reference (meat) are also systematically varied. To facilitate substitution over time it would be very interesting to explore how different types of contexts can be used as a carrier for increased acceptance of meat substitutes. For instance, how can one situational context (e.g. a restaurant, school) be used to promote the acceptance of a new food product in another context (e.g. at home)? The effect of different types of contexts

needs further study, and how this can be applied to promote the acceptance of new food products like meat substitutes.

The process of substitution

As illustrated by the margarine case, substitution processes are generally gradual processes, which takes time to be taken up by large numbers of consumers in a population. There are clearly links with Rogers' theory of diffusions of innovations (Rogers, 1995), although this has not been extensively described for the area of acceptance of food technologies and innovations (Ronteltap, Van Trijp, Renes, & Frewer, 2007). Since substitution is a time-dependent process, the time-point at which you measure influences the degree of consumer acceptance, product perceptions and wishes. Ideally, one would follow consumers for decades to get real insight in the process of substitution, which is very expensive if not impossible for consumer research purposes. As illustrated by the margarine case, there is now only population level data available, but not on how and why products were replaced over time by *individual* consumers or families.

A dynamic view on replacement of meat by meat substitutes is thus necessary, which was incorporated in this thesis as much as possible. A retrospective view was used to investigate the social/economic factors from 1870-2000 (Chapter 2), and consumers' drivers and barriers were assessed by comparing different levels of acceptance (Chapter 3). Study participants were actually followed for a period of 10 weeks to study the effects of repeated exposure on product liking. Unfortunately, changes over time on product identification or satiety experiences could not be incorporated. A practical approach to study replacement of meat by meat substitutes in future studies is the use of experimental designs with different conditions for a longer period of time (e.g. meat substitutes used as a snack or in the meal, meat substitutes that range in similarity to meat). Substitution research has mainly been applied in marketing and economic research (Ratneshwar & Shocker, 1991; Shocker, Bayus, & Kim, 2004; Wansink, 1994) and still needs to find its way into food acceptance research. These approaches would also be relevant for other types food substitutes such as light or low-fat products.

How consumer acceptance was measured: limitations and future research areas

The use of explicit or implicit measures

In most of the studies, questionnaires were used as a way of capturing consumer responses. A number of questionnaires used were based on certain constructs and/or were validated for actual consumer behaviour, such as food-related lifestyles (Grunert, Brunsø, & Bisp, 1997), food neophobia (Pliner & Hobden, 1992), food choice motives (Steptoe, Pollard, & Wardle, 1995) and satiety ratings (Hill, Rogers, & Blundell, 1995).

The use of questionnaires enabled the exploration of several aspects on consumer and consumption behaviour, among a large group of consumers, and made quantification and comparisons possible. However, direct questioning is generally questioned due to the weaknesses involved. Respondents always respond, even when the question is not appropriate, or when the underlying reasons for their likes and dislikes are not always clear to them, and filling out questionnaires brings about a certain rationalization (Dijksterhuis & Byrne, 2005; Köster, 2003; Köster, 2009; Tuorila & Monteleone, 2009). When respondents are asked to report their attitudes towards a product that they do not think about often, they will focus on the attributes that are accessible in memory, plausible as causes of their feelings, and easy to verbalize. As a consequence, the attitudes reported in a questionnaire may not fully reflect the actual attitudes (Steinman & Karpinski, 2008). This might also be true for consumers rating questions on aspects of meat and meat substitutes. Fortunately, there are research methods available that avoid direct questioning, which could be incorporated in future studies: the use of observational techniques based on ethnography (e.g. Mariampolski, 1999), measurement of facial expressions (e.g. Zeinstra, Koelen, Colindres, Kok, & De Graaf, 2009), eye tracking (e.g. Jones & Richardson, 2007), and implicit association tests (e.g. Steinman & Karpinski, 2008). The latter is a computer-based measurement technique that assesses the strength of associations between concepts in memory, and is applicable to food product research (Kraus, Möslein, & Scharf, 2009). Assessment of these implicit associations with either meat or meat substitutes could reveal the underlying meanings that these products have to consumers. This might be especially relevant due to the implicit meaning of meat in our culture. Application and validation of these implicit methods for food acceptance research need to be continued.

Capturing consumer needs and motives for future products

Novel Protein Foods do not yet exist. Fortunately there were *current* meat substitute products available to use for studies on consumer needs, perceptions, and experiences. This resulted in an understanding of the current situation and gave directions for future opportunities and next steps to be made. However, it is very difficult to translate this directly into Novel Protein Foods. It is often stated that consumers cannot articulate their need for innovative products, because they are heavily influenced by the products currently on the market, their past experiences and the today's environment (Grunert, 2008; Lilien, Morrison, Searls, Sonnack, & Von Hippel, 2002; Van Kleef, 2006). Consumers therefore cannot be expected to provide their needs and wishes on radically new products that do not yet exist. On the other hand, Novel Protein Foods eventually have to take the place of meat in existing meal patterns, so the reference to meat products will initially remain. In future studies, consumer responses to actual

new products and concepts of Novel Protein Foods should be tested to learn more about this issue.

7.3 IMPLICATIONS AND RECOMMENDATIONS

In this section the practical implications of the research findings are described and suggestions for further steps for policy makers and product developers are made (see also summary in Box 7.1).

For policy makers

Sustainability does not sell itself. Just as with any food product, a good fit of Novel Protein Foods with consumer needs and wishes is essential for success. This requires a long-term view since time, and more, is needed for these types of radical changes in eating patterns. The need to produce and consume in a more sustainable way is currently felt by government and policy makers, but not so to the majority of consumers (e.g. this thesis; Bartels et al., 2009; Lindeman & Sirelius, 2001; Shepherd, Magnusson, & Sjödén, 2005). In general, daily food choices by meat consumers are merely driven by other issues such as the sensory appeal and familiarity of foods. In addition, 'environmentally friendly' is a long-term benefit that is not directly and personally experienced by consumers (Magnusson, Arvola, Hursti, Åberg, & Sjödén, 2003). The route of reducing meat consumption by a meat substitute is thus a very bumpy road. As was described in previous sections, substituting meat with another product brings additional challenges. It needs essentially two changes in a row: one, the familiar meat is taken out, and two, a new product is put in. These two changes seemingly require double the effort for consumers to reduce the consumption of meat. Therefore it is worthwhile to explore other scenarios that avoid this: for instance by reducing the environmental impact by meat production (no change by consumers needed), promoting to eat less grams of meat without the use of a substitute (one change by consumers needed), or investigate options for *combined* plant/meat protein products. The latter option would take use of both the advantages of meat, like certain sensory properties, and the advantages of plant proteins, namely less environmental impact (Hopkins & Dacey, 2008; Kuik, 2006; Tukker et al., 2008). This type of product recently appeared on the Dutch market and it is interesting to monitor further developments. The alternative scenarios listed here are probably more acceptable to meat consumers, but this needs to be investigated still. Other policy measures, like regulations and taxes are generally not recommended (Kuik, 2006). Government and policymakers do have the opportunity to fund, coordinate and stimulate the other

actors involved, such as research and development by companies and universities and institutes (see Box 7.1).

For product developers

This thesis described the influencing factors on consumer acceptance of meat substitutes, and obviously next steps in the new product development (NPD) process still need to be made for Novel Protein Foods (see Box 7.1). The key learning for product development is that new types of meat substitutes, such as Novel Protein Foods, need further improvement in overall product quality as perceived by meat consumers. Several points of attention are formulated based on the research described in this thesis.

· Improved sensory quality

In general, meat consumers still judge the sensory appeal of meat substitutes lower than meat, and this aspect probably accounts for the largest difference in perceived quality between these two types of products (this thesis, Elzerman, 2006; McIlveen, Abraham, & Armstrong, 1999). Non-vegetarian consumers currently would like to see meat-like properties in a meat substitute. The overall appreciation thus needs to be improved further in order to be able to offer a relative advantage by Novel Protein Foods compared to meat. This requires production and processing techniques that enable mimicking the sensory properties of meat, such as the flavour, texture and juiciness (Aiking, De Boer, & Vereijken, 2006; Elzerman, 2006; Kuntz, 1995; McIlveen et al., 1999; Wiebe, 2004). Recent technological developments that enable to induce meat-like fibres holds a promise to achieve a meat-like texture (Manski, Van Der Goot, & Boom, 2007). Another interesting option is to combine both meat and plant ingredients in one product (see previous section).

· New but not *too* new

Besides a certain degree of similarity to meat with respect to the sensory characteristics taste and texture, this is also recommended for product appearance. At present, commercially available meat substitutes were already too unfamiliar to most meat consumers. An explorative study showed that concepts that were radically different from meat were not recognized as alternatives (this thesis). The perceived newness of meat substitutes is obviously a large barrier in acceptance. The target group, current meat consumers, is rather conservative, more food neophobic, and resistant to change (Foxall, 1995). It is sometimes questioned whether radical new products are generally acceptable to consumers, because these require big changes in behaviour and are therefore not compatible with current lifestyles (e.g. Heiskanen, Hyvonen, Niva, Pantzar, Timonen, & Varjonen, 2007; Kleijnen, Lee, & Wetzels, 2009).

Van Boekel (2009) suggests to opt for innovations that make use of new ingredients and technologies instead of confronting consumers with radically new foods. Such innovations behind the scenes are an interesting option for Novel Protein Foods, although care must be taken with GM and other novel processing techniques because these might be rejected by consumers (Ronteltap et al., 2007; Cardello et al., 2007). An opposite line of thinking is the call for really new products in the food domain (Grunert et al., 2008; Stewart-Knox & Mitchell, 2003). This is based on indications that original concepts are more successful than 'copy-cat' or 'me too' products (Hoban, 1998; Van Trijp & Meulenberg, 1996; Van Trijp & Steenkamp, 1998). However, newness in itself is not the key to success but only if it provides a meaningful differentiation to consumers (Van Trijp & Van Kleef, 2008). The right balance for Novel Protein Foods between new but not too new, and similar but not too similar, needs to be tested in consumer research with actual products.

· Improved satiating properties

If Novel Protein Foods are to substantially replace meat in the diet, the nutritional composition requires attention as well. Besides the consequences for health, the product composition also influences the product experience. The amount of protein plays an important role in elucidating feelings of satiety. This is a point of attention and improvement for meat substitutes, since even heavy-users indicated that satiating properties are less compared to meat. The amount of protein in Novel Protein Foods thus needs to be higher than in current meat substitutes and equal or higher than meat. More research is needed on the effects on satiety by different types of proteins, both by plant and animal proteins.

· Incorporate the meal context

The meal is of great influence on acceptance of food products, which is also true for meat and meat substitutes (e.g. Elzerman, 2006; Meiselman, 2000). The role of the meal runs via several ways, besides an impact on liking of the product itself, the overall meal liking is influenced by the appropriateness of the different individual meal components. This is currently being investigated in more detail (see Elzerman, 2006). A familiar meal can reduce the unfamiliarity of the individual meat substitute product, act as source of variation, and may refer to a similar usage situation and preparation, which facilitates product identification. Meals thus need to be incorporated in product design and consumer testing of Novel Protein Foods. This thesis focussed in particular on the product, but other aspects of the marketing mix, price, promotion and place need to be considered in new food product development as well (Urban & Hauser, 1993; Van Trijp & Meulenberg, 1996). With respect to promotion and supporting communications of Novel Protein Foods, it is to be expected that communicating the environmental

argument, e.g. by using ecolabels, will have a limited impact. In addition, it is most likely that different types of Novel Protein Foods need to be developed for different consumer segments. Next steps include a further segmentation of meat consumers with respect to Novel Protein Foods and a description of relevant consumer benefits (e.g. Verbeke, Pérez-Cueto, Barcellos, Krystallis, & Grunert, in press).

To conclude our recommendations: this project was part of the research program PROFETAS in which scientists from different disciplines were represented. Further development of Novel Protein Foods also requires a crossing of disciplines and cooperation between R&D and marketing. The use of cross-functional teams in product development has been identified as a key success factor (Cooper, 1994; Cooper & Kleinschmidt, 1996). On the one hand this has to do with sharing and integrating knowledge throughout the NPD process (Grunert et al., 2008), on the other hand there is a more emotional component to it. The commitment of project team members was found to be of particular importance in NPD and this commitment by team members can even be enhanced by tacit knowledge by the use of early prototyping of products (Macitelli, 2001). Multidisciplinary teams are important to move forward with new food product development.

7.4 OVERALL CONCLUSION

It is thus not just a matter of taking the meat out of a meal and putting the meat substitute in.

The overall aim to reduce the environmental pressure of meat production by another product, a new meat substitute as Novel Protein Foods, is a challenging route. It takes time and needs further efforts to develop a meat substitute that is attractive to meat consumers and able to substantially reduce meat consumption. While vegetarians avoid meat mainly due to ideological motives, this is and will undoubtedly not be the case with meat consumers. The environmental argument is thus not enough to sell Novel Protein Foods. Meat consumers are now held back by rather conservative personal characteristics, like the tendency to avoid new foods (food neophobia), and go for sensory attractive and familiar food products. Novel Protein Foods initially need to share some characteristics with meat in order to be used in the same way and to be preferred. This holds for the taste, appearance, the preparation, and product composition, like the amount of protein. The meat substitute route will only work when Novel Protein Foods offer certain benefits to consumers that fit consumer needs. However, it needs to be said that substitution is a very gradual process which requires

a long-term view; both for developing new products of a certain product quality, as for consumer acceptance and uptake into dietary patterns.

For policies to decrease the environmental impact by meat consumption

- ✓ Investigate and initiate other options that avoid substitution:
  - A decrease in the environmental impact caused by meat production
  - A decrease in meat consumption (without a substitute product)
  - Explore other product options, e.g. combined plant/meat protein products
- ✓ Facilitate the points below by investments in knowledge development and information transfer

For product development of Novel Protein Foods

- ✓ Improved sensory quality and similarity to meat
- ✓ Improve satiety aspects, e.g. by an increased protein content
- ✓ Investigate and develop products with the right balance of newness and similarity to meat
- ✓ Incorporate the meal context in product development and testing
- ✓ Segmentation of meat consumers and need assessment, development of different Novel Protein Foods concepts accordingly
- ✓ Take the next steps in the new product development process, starting with:
  - Idea generation and design of product concepts
  - Development of test products
  - Test the products among target consumers
  - Product optimization
- ✓ Facilitate truly multidisciplinary working with R&D and marketing and pursue further research for the issues raised (see below)

For food consumer acceptance research

- ✓ Set-up multidisciplinary research approaches
- ✓ Investigate substitution of food products, e.g. with the case Novel Protein Foods:
  - Perceptions of similarity and attributes involved
  - The role of expectations and experiences
  - Trade-offs of different attributes
  - The role of context
  - The process of substitution
- ✓ Consumer research with actual Novel Protein Foods products
- ✓ Application and validation of implicit methods for food consumer research

Box 7.1: Checklist of suggested next steps

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Summary

SUMMARY

There is currently a renewed attention for the relation between our food consumption patterns and the impact on the environment, especially for meat production. Meat production for human consumption puts a heavy burden on the environment by the use of large amounts of energy, fertilizers, water, land, and the resulting pollution. Therefore, a Dutch research program PROFETAS (www.profetas.nl) investigated options to replace meat in the diet by sustainable plant-based alternatives to meat, so called Novel Protein Foods. A point of departure is that these products should be attractive to meat consumers, being directly competitive and substitutable for meat, and should be consumed at sufficient amounts over a long period of time. However, this is not yet the case with current meat substitutes, which are estimated to have a market share of only 1-5% of the meat market. Insight in factors on consumer acceptance is needed and for that reason this thesis investigated which factors play a role in consumer acceptance of meat substitutes to reduce the consumption of meat. Substitution and acceptance of food products is generally related to several factors involving the food (both the substitute and the reference product), the person, and the environment and implies psychological, sensory, physiological, and social aspects. Therefore, a multi-disciplinary approach was used to shed more light on this complex issue. Meat substitutes that were available on the market were used as test products and the focus was on Dutch meat consumers.

In Chapter 2, the development and acceptance of different types of previous food substitutes were described in the light of *the economical/social context*. By taking a retrospective view on food substitutes, the role of technological advances, governmental policy measures, and consumer needs was considered. It seems that technological advances and governmental policy measures are mainly creating favourable preconditions for the development and market launch of food substitutes. Due to technological advances it was possible to produce high quality substitutes that mimic the reference products. This is of importance with food substitutes in the form of macronutrients (like sugar substitutes) and food substitute products (like margarine). Governmental policy measures can stimulate information transfer and increased know-how, and include regulations with respect to food safety, which have the most impact on the actual appearance of food substitutes on the market (e.g. a reason for currently not having fat substitutes on the Dutch market). However, the final replacement by food substitutes depends on consumer acceptance. Successful food substitutes were in line with consumer trends and needs (like health for sugar substitutes, convenience for breakfast drinks) and offered specific benefits. *Time* is an important factor in substitution in two ways: it is needed for further technology

advancements and product improvements, and for gradual entry in changing eating patterns and acceptance by consumers.

First of all, consumers need to have a reason to choose for meat substitutes instead of meat. Chapter 3 therefore investigated *how consumer characteristics and motives* influence consumer acceptance. Two consumer surveys illustrate how general person-related factors, such as lifestyle, food choice motives, and food neophobia (the tendency to avoid new foods), and specific attitudes and beliefs towards meat and meat substitutes, may act as drivers and barriers in acceptance. Obviously, heavy-users (mainly vegetarians) had certain ideological motives that drive their avoidance of meat, whereas this was not the case with non-users or light/medium-users of meat substitutes. These consumers were mainly interested in the sensory appeal and the familiarity of foods. The personal trait food neophobia was an important barrier for first trial of meat substitutes. But most of all, the overall attitudes and beliefs towards the products determined acceptance. An overall negative attitude towards meat substitutes was related to a lower degree of acceptance. Meat substitutes scored particularly lower than meat on sensory attractiveness and familiarity, which are in fact the most important aspects to meat consumers. In addition, the fewer consumers were using meat substitutes, the more they wanted these products to be similar to meat.

Secondly, the identification of a new meat substitute product as an alternative for meat on the plate is important. In Chapter 4 the *identification of meat substitutes* and meat was explored by means of the categorization theory. The question was how consumers perceive and categorize meat products, meat substitutes and radically new concepts of Novel Protein Foods. The performed study demonstrated how consumer perceptions are largely influenced by a deep-rooted taxonomic classification of meat (e.g. 'beef', 'pork'). Similarity of meat substitutes to meat was essential to be grouped in a meat category and to be regarded as alternatives by meat consumers. As a result, meat substitutes were grouped separately from non-processed meat products. However, processed products more similar in appearance and with a similar application in meals, like 'pieces' and 'sausages', were grouped together. In contrast, radically new concepts were regarded as a completely different food category, not to be used as a substitute for meat.

In the third place, consumption of meat substitutes needs to result in comparable product experiences, such as feelings of satiety. Chapter 5 therefore dealt with the *physiological effects*, namely *satiety*, after eating meat substitutes. The relative protein content of a product is of particular importance for satiety after consumption. A product inventory showed that current meat substitutes on the Dutch market have generally a lower protein content compared to meat products. An actual consumption study with commercially available meat and meat substitutes that varied in protein

content, confirmed the effect of protein levels on perceived satiety: meat substitutes with a low protein content were less satiating. Noticeably, meat substitutes with a high protein content were able to induce even higher satiety feelings than the meat reference products. Since heavy-users of meat substitutes also indicated that the satiating properties of these products need to be improved (Chapter 3), this consumer-relevant attribute needs further attention in product development of Novel Protein Foods.

Finally, it should be possible to eat meat substitutes on a very regular basis. Thus, in Chapter 6 *the dynamics in liking over time* were investigated by a repeated consumption study. The question was whether meat substitutes, either similar (Quorn) or dissimilar (tofu) to the reference meat product (chicken), were accepted better over time or whether consumers got bored with it. The meat reference was initially liked better, but after twenty exposures the meat substitutes and meat reference were equally liked. There were different individual responses by study participants; both boredom and increased liking patterns were observed. Surprisingly, there was a high number of individuals that increasingly liked the meat substitute dissimilar to meat (tofu). This is in line with mere exposure effects, implicating that unfamiliar products are liked better after repeated use. Another striking result of the study is the role and the importance of the meal in liking over time: participants used other meal components to introduce variation and alleviate boredom with the product.

Chapter 7 described the main findings and overall conclusion of the research and discussed the methodological issues and suggestions for further research. The application of Novel Protein Foods is clearly not just a matter of taking the meat out of a meal and putting the meat substitute in. Meat consumption is anchored in our culinary culture and it will take time to change this. The option to use meat substitutes to replace meat on the plate is accompanied by some specific challenges; it includes a direct comparison and competition with meat. Currently, most meat consumers do not have a reason to choose for meat substitutes because these products do not fit their needs or motives. This is complemented by considerable barriers to use meat substitutes: food neophobia, the unfamiliarity of these relatively new products, and a lesser perceived product quality than meat. If Novel Protein Foods need to substantially replace meat in the diet, this product needs to offer a comparable overall product quality and certain benefits to consumers. At the present time, it seems too early to introduce products that are radically new. A certain degree of similarity to meat is preferred in terms of sensory characteristics, satiating properties, and overall appearance, in order to be recognized and applied in a similar way.

Similarity to meat thus seems a crucial issue and further studies need to identify what the essential characteristics are, how to incorporate this in the design of Novel Protein Foods, and how this subsequently affects substitution of meat by consumers.

The similarity to specific sensory properties of meat obviously plays a role. More information is needed on which texture and flavour properties are involved, how these can be developed, and how these affect product liking. The appropriateness in meals and the role of the meal context are also of importance. These issues are investigated further by another PhD project of the PROFETAS program. Besides the product taste, the right balance between overall perceived similarity to meat and the degree of newness needs to be considered and tested.

Substitution by plant-based meat substitutes obviously takes time and it is therefore worthwhile to investigate other options as well. This includes further exploration of possibilities with combined plant/meat protein products and other routes to decrease meat consumption without the use of substitutes.

Samenvatting

SAMENVATTING

Er is op dit moment opnieuw veel aandacht voor de relatie tussen onze eetpatronen en de impact op het milieu, en met name voor de productie en consumptie van vlees. Vleesproductie is milieubelastend door de grote benodigde hoeveelheden energie, kunstmest, water, land, en resulteert in milieuvervuiling. In het Nederlandse onderzoeksprogramma PROFETAS (www.profetas.nl) werden daarom de mogelijkheden onderzocht om de consumptie van vlees te vervangen met milieuvriendelijke plantaardige alternatieven, zogenaamde Novel Protein Foods. Een belangrijk uitgangspunt hierbij was dat deze producten aantrekkelijk moeten zijn voor vleesconsumenten, moeten kunnen concurreren met vlees en dit kunnen vervangen, en in voldoende hoeveelheden gedurende een lange tijdsperiode gegeten moeten kunnen worden. Dit is nog niet het geval met de huidige vleesvervangers, met een marktaandeel van ongeveer 1-5% van de vleesmarkt. Er is dus meer inzicht nodig in hoe de acceptatie door consumenten tot stand komt. In dit proefschrift werd daarom onderzocht welke factoren een rol spelen in consumentenacceptatie van vleesvervangers voor het vervangen van de consumptie van vlees. De vervanging en acceptatie van voedingsmiddelen hangt over het algemeen samen met verschillende factoren met betrekking tot het product (zowel de vervanger als het referentieproduct), de persoon, de omgeving, en omvat psychologische, sensorische, fysiologische, en sociale aspecten. Daarom werd een multidisciplinaire aanpak toegepast om zo meer inzicht te krijgen in deze complexe kwestie. De focus in het onderzoek lag op Nederlandse vleesconsumenten en de testproducten waren vleesvervangers die al op de markt waren.

Hoofdstuk 2 beschreef het ontstaan en de acceptatie van verschillende typen vervangers in het licht van de *economische/sociale* context. De rol van technologische ontwikkelingen, het beleid van de overheid, en de consumententrends en -behoeften werden vanuit een historisch perspectief beschouwd. Hieruit blijkt dat de technologische vooruitgang en het beleid van de overheid met name een positieve invloed hadden op het creëren van gunstige (rand)voorwaarden voor de ontwikkeling en het op de markt brengen van vervangers. Door de technologische vooruitgang was het mogelijk om vervangers te maken van zeer goede kwaliteit die in grote mate lijken op hun referentieproducten. Dit is vooral belangrijk bij vervangers van macronutriënten (zoals suikervervangers) en bepaalde producten (zoals margarine). De overheid kon een rol spelen in de toename van bepaalde kennis en het verspreiden van informatie, maar ook met wetgeving zoals op het gebied van voedselveiligheid. De wetgeving heeft het meeste impact op het op de markt brengen van vervangers (dit is een reden waarom er in Nederland geen vetvervangers op de markt zijn). Echter, de mate van vervanging van voedingsmiddelen door vervangers

hangt uiteindelijk af van consumentenacceptatie. Succesvolle vervangers sloten aan op consumententrends en -behoeften (zoals gezondheid voor suikervervangers en gemak voor ontbijtvervangers) en boden consumenten daarmee bepaalde voordelen. Tijd was ook een belangrijke factor in vervanging: tijd was zowel nodig voor verdere technologische ontwikkelingen en productverbeteringen, als voor de geleidelijke acceptatie door consumenten en het passen in veranderende eetpatronen.

Consumenten moeten in de eerste plaats een bepaalde reden hebben om voor vleesvervangers te kiezen in plaats van vlees. In Hoofdstuk 3 werd daarom de invloed van *consumenteneigenschappen en -motieven* op acceptatie onderzocht. Twee surveys illustreerden dat barrières en drijfveren in consumentenacceptatie zich afspelen op het niveau van algemene persoonsgerelateerde factoren, zoals lifestyle, voedselkeuze motieven en food neophobia (de angst voor nieuwe voedingsmiddelen), en op het niveau van specifieke houdingen en opvattingen ten aanzien van de producten vlees en vleesvervangers. Terwijl 'heavy-users' van vleesvervangers (vooral vegetariërs) bepaalde ideologische motieven hadden voor het vermijden van vlees, was dit duidelijk niet het geval bij 'non-users' of 'light/medium-users' van vleesvervangers. Deze laatste groepen consumenten waren vooral geïnteresseerd in de sensorische aantrekkelijkheid en bekendheid van voedingsmiddelen. De persoonlijke eigenschap food neophobia was vooral een belangrijke barrière voor de eerste keer proberen van vleesvervangers. Maar bovenal bleek de algehele houding en opvattingen over de producten het meest de acceptatie te bepalen: een negatieve houding ten aanzien van vleesvervangers resulteerde in een lage acceptatie. Vleesvervangers scoorden vooral laag op sensorische aantrekkelijkheid en bekendheid, terwijl dit nu juist de aspecten zijn die belangrijk gevonden worden door vleesconsumenten. Verder was opvallend dat hoe minder vaak consumenten vleesvervangers gebruikten, des te meer zij wilden dat deze producten op vlees lijken.

Ten tweede is het van belang dat een nieuwe vleesvervanger ook daadwerkelijk herkend wordt als een alternatief voor vlees in de maaltijd. Om deze reden werd in Hoofdstuk 4 de *identificatie van vleesvervangers* en vlees verkend door middel van de categorisatie theorie. De vraag was hoe consumenten een aantal vleesproducten, vleesvervangers, en radicaal nieuwe concepten van Novel Protein Foods zouden waarnemen en categoriseren. De studie toonde aan dat de perceptie van consumenten grotendeels beïnvloed is door een diepgewortelde taxonomische indeling van vlees (zoals 'rund', 'varken'). Voor vleesconsumenten bleek een bepaalde mate van overeenkomst van vleesvervangers met vlees essentieel om vleesvervangers samen met vleesproducten te groeperen en deze te beschouwen als een alternatief voor vlees. Vleesvervangers werden daarom niet gegroepeerd met onbewerkte vleesproducten. Bewerkte producten die overeenkwamen in uiterlijk en met een gelijke toepassing in maaltijden, zoals 'stukjes' en 'worsten' werden wel samen geplaatst. De radicaal

nieuwe concepten van Novel Protein Foods werden echter als een compleet andere categorie beschouwd, en daarmee niet als vervangers voor vlees.

Ten derde zou de consumptie van vleesvervangers tot eenzelfde productbeleving als met vlees moeten leiden, zoals het gevoel van verzadiging. Hoofdstuk 5 ging daarom in op de *fysiologische effecten*, namelijk *verzadiging*, na het eten van vleesvervangers. Met name het relatieve eiwitgehalte van een product speelt een belangrijke rol in verzadiging. Een inventarisatie van vlees en vleesvervangende producten illustreerde dat de vleesvervangers op de Nederlandse markt over het algemeen een lager eiwitgehalte hebben dan vlees. Een consumptiestudie met commercieel verkrijgbare vlees en vleesvervangers variërend in eiwitgehalte bevestigde het effect van eiwit op verzadigingsgevoel: vleesvervangers met een laag eiwitgehalte verzadigden minder. Opvallend was dat vleesvervangers met een hoog eiwitgehalte zelfs tot een sterker gevoel van verzadiging leidden dan de referentie vleesproducten. Gezien 'heavy-users' van vleesvervangers al eerder aangaven dat de verzadigende eigenschappen van deze producten verbetering behoeven, verdient deze relevante producteigenschap meer aandacht in de verdere productontwikkeling van Novel Protein Foods.

Tot slot moet het mogelijk zijn om vleesvervangers regelmatig te eten. In Hoofdstuk 6 werd daarom *de verandering in waardering over langere tijd* bestudeerd door een studie met herhaalde blootstelling. De vraag was of vleesvervangers die meer lijken op vlees (zoals Quorn) of minder lijken op vlees (tofu), beter gewaardeerd werden of gingen vervelen op lange termijn, in vergelijking tot een vleesreferentie (kip). In het begin werd de vleesreferentie meer gewaardeerd, maar na 20 consumpties werd de waardering voor de vleesvervangers en vleesreferentie ongeveer gelijk. Er waren duidelijk individuele verschillen in de reacties van de deelnemers: zowel verveling als een toegenomen waardering kwamen voor. Het was echter verrassend dat er een groter aantal individuen de vleesvervanger die minder op vlees lijkt op (tofu) meer ging waarderen na verloop van tijd. Dit is in overeenstemming met het 'mere exposure' effect dat inhoudt dat onbekende producten beter gewaardeerd worden na herhaaldelijk gebruik. Een ander opvallend resultaat van de studie was de rol van de maaltijd op productwaardering over de tijd: deelnemers gebruikten een variatie in de andere maaltijdcomponenten om de verveling te verminderen.

Hoofdstuk 7 beschreef de hoofdbevindingen en algehele conclusie van het onderzoek, en bediscussieert de methodologische aspecten en mogelijkheden voor verder onderzoek. De toepassing van Novel Protein Foods is duidelijk niet kwestie van het vlees uit de maaltijd halen en er een vleesvervanger voor in de plaats leggen. Vleesconsumptie is verankerd in onze eetpatronen en –gewoonten, en het zal dan ook tijd kosten om dit te veranderen. De toepassing van vleesvervangers om de consumptie van vlees te vervangen gaat dan ook gepaard met specifieke uitdagingen; een directe vergelijking en competitie met vlees. Vleeseters hebben op dit moment geen reden

om voor vleesvervangers te kiezen omdat deze producten niet aansluiten bij hun behoeften of voedselkeuzemotieven. Dit wordt verder versterkt door aanzienlijke barrières om vleesvervangers te gebruiken: food neophobia, de onbekendheid van deze relatieve nieuwe producten, en een lagere productkwaliteit. Indien Novel Protein Foods voor een substantieel deel vlees dienen te vervangen, moeten deze producten een vergelijkbare productkwaliteit hebben en bepaalde voordelen bieden aan consumenten. Op dit moment lijkt het nog te vroeg om producten te introduceren die radicaal nieuw zijn. Om herkend en gebruikt te worden als een vervanger van vlees is voor een nieuwe product een bepaalde gelijkenis met vlees met betrekking tot de sensorische eigenschappen, verzadigende eigenschappen, en het uiterlijk gewenst. De gelijkenis met vlees is dus een cruciaal punt en vervolgstudies zouden zich daarom kunnen richten op het achterhalen van de essentiële producteigenschappen, hoe dit meegenomen kan worden in het productontwerp en de ontwikkeling van Novel Protein Foods, en hoe dit uiteindelijk de vervanging van vlees door consumenten beïnvloedt. De gelijkenis met bepaalde sensorische eigenschappen van vlees speelt kennelijk een belangrijke rol. Meer informatie is nodig over de betrokken textuur- en smaakeigenschappen, hoe deze ontwikkeld kunnen worden, en hoe deze uiteindelijk de consumentenwaardering beïnvloeden. De passendheid in maaltijden en de maaltijdcontext is ook belangrijk. Deze aspecten zijn onderzocht door een ander PhD onderzoek van het PROFETAS programma. Behalve de smaak van het product, moet de juiste balans gevonden worden tussen de overeenkomst met vlees en een bepaalde mate van nieuwheid.

Het gaat een aanzienlijke tijd duren voordat vlees door plantaardige vleesvervangers zal worden vervangen. Het is daarom zeer de moeite waard om ook andere opties verder te onderzoeken voor een vermindering van de vleesconsumptie, zoals de mogelijkheden van een gecombineerd plantaardig/vlees eiwitproduct.

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friends

About the author

ABOUT THE AUTHOR

The interests and career of Annet Hoek (born 1973, The Netherlands) can essentially be described by 3 keywords: Products, Behaviour, and Foods.

It first started with *products* and product design. After graduation from secondary school (1991), Annet went to Delft University of Technology and obtained the 'propedeuse' (preliminary exams) in Industrial Design Engineering (1993). At that time, she became more curious about 'living objects': How are they build? How and why do they *behave and react* as they do? She therefore continued her studies in Biology at Leiden University and graduated in 1998 (MSc degree). The passion for *food and nutrition* started at the physiological side, but extended more and more to the psychological aspects of eating and foods. Besides her work in commercial positions, she followed a part-time course in Human Nutrition and Metabolism (University of Sheffield, UK) until 2004 and obtained her MMedSci degree. In 2001, she started at Wageningen University with the PhD project described in this thesis, which actually combined her 3 main interests. The design, coordination, and execution of the consumer studies were alternated with other valuable activities: e.g. lecturing, supervision of 10 MSc students, and the organisation of a visiting tour and symposia for fellow PhD's in Australia. After 4 years of doing consumer research at the university, Annet went to focus more on the practical side. She worked with, and for, food companies on several food-related topics in which 'the consumer' is central: e.g. qualitative consumer research and consultancy, set-up and coordination of a nutrition & health activity plan for the Dutch food and grocery industry, establishing a consumer-orientation in R&D departments, and organisation of several symposia on foods and innovation.

Annet will continue with her passion to bridge different disciplines and worlds by bringing different people and ideas together: from science and daily practise, and from marketing and R&D. Meeting interesting people who enjoy good food, drinks, and discussions is a lucky incidental circumstance of the job.

OVERVIEW OF COMPLETED TRAINING ACTIVITIES

Discipline specific activities

Courses

- Nutritional and lifestyle epidemiology, VLAG, Wageningen, Nl, 2001
- Targeting the Consumer, Hal Macfie Training, UK, 2001
- Food perception and food preference, VLAG, Wageningen, Nl, 2003

Meetings

- BSE congress, Ede, Nl, 2001
- Pangborn Sensory Science Symposium , Dijon, France, 2001
- IFHE congress, Wageningen, Nl, 2001
- Food Choice congress, Wageningen, Nl, 2002
- Pangborn Sensory Science Symposium, Boston, USA, 2003
- European Conference on Sensory Science of Food and Beverages, Florence, Italy, 2004

General courses

- PhD introduction week , VLAG, NL, 2001
- Scientific writing, CENTA, Wageningen, Nl, 2002
- Part of MMedSci Human Nutrition / distance learning modules, The University of Sheffield, UK, 2001-2004

Optional courses and activities

- Participation Phd Tour Italy, Division of Human Nutrition, Wageningen University, 2001
- Organisation and participation Phd Tour Australia, Division of Human Nutrition, Wageningen University, 2003
- Meetings WEVO (Werkgroep Voedingsgewoonten), Nl, 2001-2004

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