Public acceptance of nutrigenomics-based personalised nutrition

Exploring the future with experts and consumers

Amber Ronteltap

Promotor: prof. dr. ir. J.C.M. van Trijp
Hoogleraar in marktkunde en consumentengedrag
Wageningen Universiteit

Co-promotor: dr. R.J. Renes
Universitair hoofddocent, sectie communicatiewetenschap
Wageningen Universiteit

Promotiecommissie: prof. dr. K.G. Grunert, The Aarhus School of Business, Denmark
prof. dr. M.R. Müller, Wageningen Universiteit, Nederland
prof. dr. R. Shepherd, University of Surrey, United Kingdom
prof. dr. C.M.J. van Woerkum, Wageningen Universiteit, Nederland

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ABSTRACT

Nutrigenomics is a recent discipline within nutrition sciences that aims at understanding how food components influence health status by affecting gene expression to eventually help maintain health and prevent disease. Nutrigenomics science has a potential consumer application in the form of so-called personalised nutrition: tailored dietary advice or even personalised food products that help consumers to select foods that are optimally aligned with their genetic constitution. However, due to the fact that nutrigenomics is an emerging science and personalised nutrition is still at an early stage of development, the views of both expert and lay stakeholders on the meaning, potential, and acceptability of personalised nutrition may still be divergent and developing. This dissertation takes up the challenge of understanding and anticipating public acceptance of nutrigenomics-based personalised nutrition. It aims to answer the central research question: What determines public acceptance of nutrigenomics-based personalised nutrition? For this purpose, three lines of research are explored: development of a conceptual research framework from existing literature, expert views on the future of personalised nutrition, and consumer evaluations of different scenarios under which personalised nutrition might enter the market place.

The thesis' theoretical contribution lies in an in-depth analysis of the concept of personalisation using marketing and consumer behaviour literature (*chapter 2*), and the development of a conceptual framework for consumer acceptance of food innovations (*chapter 3*). Empirically, results from a consumer study within a representative sample of Dutch consumers (*chapter 5*) reveal that freedom of choice, clear advantages, ease of applying personalised nutrition, and consensus among experts are important factors in enhancing consumer acceptance. However, the research in this thesis also shows that experts have not yet reached the necessary consensus on the scope and potential of nutrigenomics (*chapter 4*), and that experts do not expect that it will be easy for consumers to incorporate personalised nutrition into their daily lives (*chapter 6*). These, and other, issues can serve as inspiration for future research, as well as the further refinement of the generic framework for consumer acceptance of food innovations.

In conclusion, this thesis contributes to a better understanding of how public acceptance of the scientific innovation of nutrigenomics-based personalised nutrition comes about. It shows how issues critical for the further development of such an emerging science and the innovations arising from it can be systematically identified and addressed.

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CONTENTS

1

General introduction

Humans hold an intimate relationship with the foods they consume. Not only does nutrition provide the necessary fuel for the body, it also carries strong hedonic and social values. It has become clear that not just the caloric value of the food (i.e. quantity) but also the more specific nutritional composition (i.e. quality) of the diet has a huge impact on the body's performance and health state. Over two millennia of human nutrition research highlight a strong interest in how foods and nutrients affect a human body and its performance. The first physician Hippocrates already described how nutrition formed the body's *'innate heat'* (Mehrotra, 2004), and recognised the importance of proper nutrition as he advised: *"let your food be your medicine"*. Later, the so-called Chemical Revolution led to the discovery of food's main elements or macronutrients of carbohydrates, proteins and fats (Carpenter, 2003), followed by the Biological era that taught us about micronutrients like vitamins and minerals, and the functions of food components at molecular level (Mehrotra, 2004). In short, nutrition research has developed from the body as unit of study towards increasingly small units like tissues, organs, and cells, accompanied by the study of ever more specific physiological processes. Furthermore, nutrition research has narrowed down from population to subgroup and towards individual level. These developments still continue.

"Nutrigenomics will revolutionize wellness and disease management. By being able to elucidate genetic profiles of individuals, diets will be formulated from crop to fork to confer prevention or retard disease progression. As basic science advances converge with e-commerce, new opportunities will emerge to deliver to consumers, whose genetic susceptibility to specific diets and diseases are known, products tailored to individual dietary needs."

Guy Miller M.D., Ph.D.,

chairman and CEO of Galileo Laboratories, Inc.

The challenge of nutrigenomics

By many, a next major breakthrough in nutritional sciences is recognised in nutrigenomics, one of the spin offs of the Human Genome Project in which the sequence of the chemical base pairs (~3 billion) that make up human DNA was identified (Collins, Morgan, & Patrinos, 2003). Genomics research focuses on how the human genome interacts with environmental factors to determine gene expression. Gene expression is responsible for how a person looks and how his body responds to environmental cues. One important environmental factor to which the genome is sensitive in its gene expression is nutrient exposure by food intake. The scientific discipline that aims at understanding how food components influence health status by affecting gene expression is nutrigenomics. Insights from nutrigenomics can bring the nutritional sciences to a next level (German & Watzke, 2004; Mehrotra, 2004; Mutch, Wahli, & Williamson, 2005), by providing more detailed insight into the processes of how nutrient exposure (and hence food intake) lead to diet-related diseases. It can also lead to a better understanding of relevant individual differences in sensitivity to diet-related disease. As such, nutrigenomics may ultimately help support disease prevention and do so at an increasingly personalised level (i.e. personalised nutrition). Personalising dietary recommendations in the form of both information and targeted food products would greatly increase their relevance and thereby efficacy to individuals. Personalised nutrition is in line with the trend of personalisation in food marketing more generally (Sutton, 2007). In this thesis, personalised nutrition is used as the operational concept representing nutrigenomics science in use.

However, despite its potential of providing better health with personalised nutrition as a tool, the further development of nutrigenomics is not without its specific challenges. This is largely due to the fact that nutrigenomics is still under construction. As a consequence, its future is unknown and surrounded with a considerable amount of uncertainty. For example, different stakeholders (e.g. scientists, media, government, NGOs, marketeers) may still have quite diverging and malleable views on the exact meaning, scope and potential of nutrigenomics as a science and in terms of the innovations that emerge from it. The outcome of this stakeholder debate can have profound impact not only on the exact manifestation (products and services) of nutrigenomics in society, but also on the intensity, tone of voice and consistency of the communication surrounding nutrigenomics and its applications. From a consumer perspective, perceptions may still be in the formation process and unstable, because consumers are unfamiliar with the new technology and their thoughts have not yet fully crystallised. This also brings in a methodological challenge when the goal is to investigate consumer perceptions and acceptance of nutrigenomics. Specifically, both the criteria consumers use to evaluate nutrigenomics applications such as personalised nutrition and their perceptions of personalised nutrition on these evaluation criteria are unknown. However, from the sheer nature of personalised nutrition as a spin off from nutrigenomics, some insights into evaluation criteria may be derived from previous studies on (a) consumer acceptance of food innovations more generally, (b) stakeholder views on nutrigenomics, and (c) consumer acceptance of other issues related to the use of genetic information.

Research on consumer acceptance of innovations more generally has shown that public uptake is largely driven by perceptions of usefulness and ease of use (Lee, Kozar, & Larsen, 2003; Tornatzky & Klein, 1982; Venkatesh, Morris, Davis, & Davis, 2003). This will likely not be different for personalised nutrition. Put in other words, people will critically evaluate nutrigenomics and personalised nutrition on the basis of their perceived benefits. These benefits can either accrue to the consumer personally (direct benefits) or to another group in society (indirect benefits). Direct and personal benefits emerge from products and services tailored to consumers' unique needs in order to improve their health. However, consumers may also value potential benefits to other stakeholders because in the long run this may support the availability of products that enhance consumers' health. For example, science and technology may benefit in the short run, the spin-off of which will benefit the consumer in the longer run. Similarly, commercial parties such as food companies may benefit from nutrigenomics in the short run enabling them to further optimise the health product assortment, from which consumers will benefit in the long run.

Stakeholder views are critically important in the further shaping of nutrigenomics and personal nutrition. Each group of expert stakeholders has its own specific area of influence; academics develop scientific substantiation, policymakers are responsible for the legislative boundaries, food industry needs to produce the consumer applications, non-governmental interest groups play an important role in citizen protection and in shaping public opinion, health professionals are highly trusted sources of health information, and the media are crucial in the dissemination of information. Besides, there are many areas for which multiple stakeholder groups have a joint responsibility, for example funding of research, or communication towards the public. Understanding these different perspectives and integrating them is crucial in anticipating the future of the emerging areas of nutrigenomics and personalised nutrition.

Finally, one specific feature of nutrigenomics is likely to play a prominent role, namely that it is concerned with the core of existence: genes. Given the poor status of consumer acceptance of other gene-related technologies (e.g. stem cell research) in Europe (Joost et al., 2007), this is not a good omen for public acceptance of personalised nutrition. The successful development of nutrigenomics-based personalised nutrition is critically dependent on consumers making available their genetic make-up, which may bring in a number of consumer concerns particularly related to privacy and potential misuse of genetic information. After all, this information is also highly interesting for employers and insurance companies among other market parties.

This dissertation takes up the key challenges outlined above and aims to anticipate consumer perceptions and acceptance of nutrigenomics-based personalised nutrition at an early stage of its development. We approach the issue from a multi-stakeholder perspective in which we include both expert stakeholder views on critical success and failure factors for the development of nutrigenomics-based personalised nutrition, and consumer evaluations of different scenarios for the arrival of personalised nutrition onto the market place. Such analysis will fill an existing gap in the scientific literature, but will also provide specific guidance on how nutrigenomics-based personalised nutrition can best be positioned to be in line with consumer needs, wants and concerns.

Scope and outline of this thesis

The central research question of this thesis is:

What determines public acceptance of nutrigenomics-based personalised nutrition?

Three lines of research are explored for this purpose.
First, previous scientific work is reviewed to delineate the theoretical background. This part of the thesis seeks an answer to the question:

How does public acceptance of personalisation and new technologies come about in general?

In chapter 2 (van Trijp & Ronteltap, 2007) the concept of personalisation is analysed, making use of a broad body of marketing and consumer behaviour theory. It treats the historical development of adjusting products and services to consumer needs and discusses models for personalisation. Chapter 3 (Ronteltap, van Trijp, Renes, & Frewer, 2007) develops a comprehensive conceptual framework for consumer acceptance of technology-based food innovations, based on previous research from within and outside the food domain.

Second, insights and expectations from the field of expert stakeholders are collected, integrated and utilised to shed light on potential development directions for nutrigenomics. The research question to be answered by this second part is:

What are expert views on critical success and failure factors for nutrigenomics?

In chapter 4 (Ronteltap, van Trijp, & Renes, 2007) an overview of the critical factors for nutrigenomics is built on the opinions of a broad spectrum of Dutch experts.

Third, consumer opinions are included by means of anticipatory consumer research. This third part aims to answer the following question:

Which factors influence consumer acceptance of nutrigenomics-based personalised nutrition?

Chapter 5 (Ronteltap, Van Trijp, & Renes, in press) reports a large-scale study in which Dutch consumers evaluate systematically varied scenarios for the future of nutrigenomics-based personalised nutrition. These scenarios are based on insights from both theory and research among experts. In chapter 6 (Ronteltap, Van Trijp, & Renes, 2008), expert and consumer views on the future of nutrigenomics are brought together, in terms of both likelihood and desirability.

Chapter 7 concludes the dissertation providing a general discussion of the results and an analysis of the marketing potential of nutrigenomics-based personalised nutrition, together with an analysis of limitations of the study and recommendations for future research. Figure 1.1 provides an overview of the different chapters and their interrelationships and can serve as a bookmark for further reading.

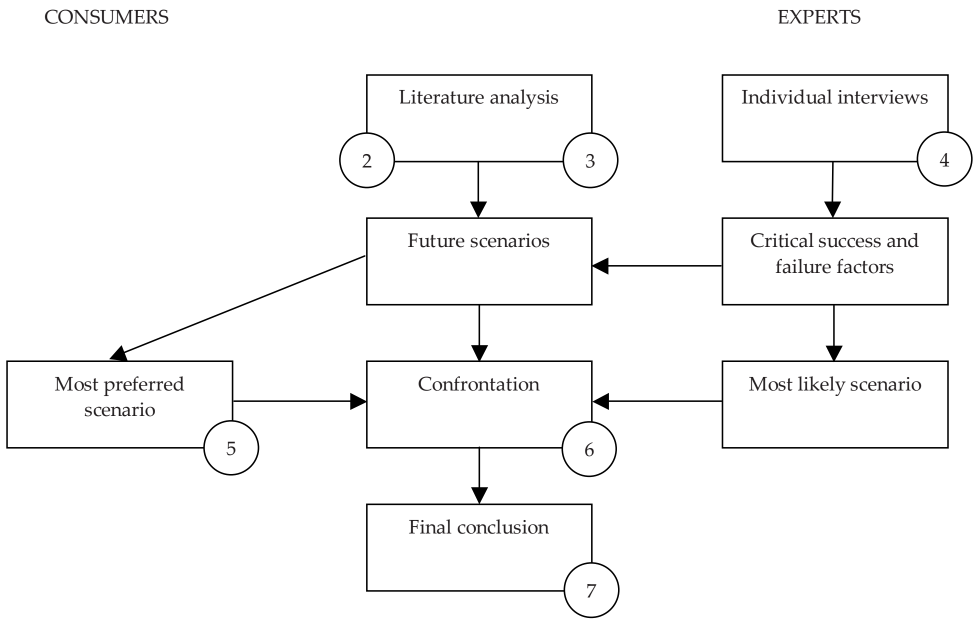

Figure 1.1. Schematic outline of the thesis (numbers correspond to chapters)

2

PERSONALISED NUTRITION

An analysis of the concept

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Introduction

The emerging science of nutrigenomics holds the potential of bringing a diversity of benefits to society through a better understanding of the fundamental processes that underpin diet-related health, vitality and disease development. However, many of these benefits will largely reside in the medical and nutritional sciences domains without the consumer necessarily noticing them. As we argued in the introductory chapter personalised nutrition, either personalised food products or nutritional recommendations, is the most likely visible commercialisation of nutrigenomics research in the consumer market. This is a potentially promising avenue as it is in line with a more general marketing trend towards personalisation that emerges in many different fields. However, genomics-based personalised nutrition stretches the boundaries of traditional personalisation approaches in at least two important ways. First, it goes against the dominant business model in food marketing that is largely based on mass-marketing and mass-distribution as a result of years of increasing efficiency in manufacturing capacity. Second, it relies upon the consumer disclosing highly intimate information on his or her genetic constitution; information that is stable, fundamental and distinctive, and can easily be (ab)used for other purposes (i.e. the privacy issue). Hence, within the domain of food marketing, genomics-based personalisation is a revolutionary development that brings in a number of specific challenges both at a marketing and consumer acceptance level.

Personalisation is a central concept in this thesis. As a thorough understanding of this concept and the consequences of applying it to nutrition are crucial to place the subsequent chapters of this thesis in a proper context, this chapter analyses personalisation in-depth. Building on marketing and consumer behaviour literature, it introduces personalisation from a marketing perspective, characterises personalisation and related notions, reviews more fundamental process models for personalisation, and analyses the specific costs and benefits involved in personalised nutrition.

Personalisation from a marketing perspective

Adjusting marketing offerings to the identified needs and wants of consumers is at the heart of the marketing philosophy (e.g. Kotler & Keller, 2006). Essentially, marketing aims to achieve an exchange of values for the mutual benefit of both the customer and the supplier. What the customer receives in terms of need satisfaction from products or services and gives in terms of monetary and non-monetary sacrifices to obtain the product is the mirror image of what the supply chain provides in terms of products and services, and receives in terms of money to satisfy its financial objectives of the value exchange. This process benefits both parties: the customer benefits from superior need satisfaction through consumption, while the supplier's benefits are financial means for growth and business continuity. When there are many customers and multiple suppliers, the processes of segmenting, targeting, and positioning become crucial. In other words, companies attempt to understand heterogeneity in consumer preferences, identify promising market segments and position their marketing offerings (products and services) for maximum benefit. In strategic marketing this is known as the STP process: segmenting, targeting, and positioning.

Historically, how this adjustment of marketing offerings to consumer needs has been achieved has depended largely on the market situation and the relative power of consumers and suppliers in the market economy. In the early days, many of the products were – literally – tailor-made. The industrial revolution changed the situation considerably. Economies of scale became a fact and it became possible to produce products economically on a large-scale basis. The key concerns were efficiency and the price of products, and the degree of personalisation is probably best exemplified by Henry Ford, who in the 1920s stated that: *"Any customer can have a car painted any colour that he wants so long as it is black."* Later, when markets became more abundant, supply more differentiated, and consumers exhibited greater purchasing power and more sophisticated articulation of their needs, market segmentation and product positioning became more crucial in the marketing process. Companies began to produce and market differentiated products targeted at identified market segments.

In the late 20th century this process reached a new level (Pine & Gilmore, 1999; Sheth, Sisodia, & Sharma, 2000; Wind & Rangaswamy, 2001). Companies now realise that the crucial objective of marketing strategy is customer value, that demand is heterogeneous and fragmented, that consumer segments are diminishing in size, and that the crucial element in competitiveness and marketing success has become the fit with the individual consumer. The variety of product and service is important, but as Pine, Peppers, and Rogers (1995, p. 103) state: *"Customers, whether consumers or businesses, do not want more choices. They want exactly what they want – when, where and how they want it – and technology now makes it possible for companies to give it to them."* A key concept in this trend is personalisation. Personalisation is about *"building consumer loyalty by building a meaningful one-to-one relationship; by understanding the needs of each individual and helping satisfy a goal that efficiently and knowledgeably addresses each individual's needs in a given context"* (Riecken, 2000, p. 27). So, personalisation is about reducing the information gap between consumers and the supply chain (information asymmetry), beyond the level of traditional segmentation. It implies a degree of interactivity between supply chains and consumers, such that information about the consumer becomes available in an actionable format and that the fit of marketing offerings with those needs becomes more explicit. Personalisation is central to the firm's customer relationship management (CRM) and to customer involvement, such as through consumer intimacy strategy (e.g. Treacy & Wiersema, 1993).

Personalisation has pervaded many different fields, most prominently that of digital products and services where it is relatively easy to obtain and analyse consumer input interactively and adjust the marketing offerings accordingly. The field of nutrition, too, is becoming increasingly affected by personalisation, both in terms of information provision and in terms of products tailored on the basis of consumer information (Bouwman et al., 2005; Brug, Campbell, & van Assema, 1999; Brug, Oenema, & Campbell, 2003). The recent advances in nutrigenomics have given extra impetus to the field of personalised nutrition. The Institute of the Future defines personalised nutrition as *"the application by individuals of their knowledge of nutrigenomics to their everyday decisions about nutrition"* (Cain & Schmid, 2003, p. 2). However, we believe that personalisation goes beyond the field of genetics and includes other information related to personal preferences as well, such as perceived state of health, tastes, values, and other relevant segmentation variables.

Personalisation in the field of human nutrition provides great potential to all stakeholders, including the consumer, the firm, and those concerned with public health. The process of personalisation provides consumers with the opportunity to find an offer that is better tailored to their specific needs. This might be in the form of nutritional information, personal advice, and even customised food products. In this way, personalisation may also help consumers to reduce their search and evaluation costs in product choice behaviour. For the firm, personalisation may help to distinguish it from competitors, build customer relationships, and increase customer loyalty. If well executed and substantiated in nutritional science, personalised nutrition may contribute to the improvement of public health. However, there are benefits and costs associated with personalisation – both to the individual consumer and to the company.

Personalisation and customisation

Although personalisation has quite a long history, particularly in the ICT area, there is still a lack of consensus about its definition (Vesanen & Raulas, 2006). Also, personalisation has been approached from many different perspectives (Riecken, 2000). Table 2.1 provides an overview of various definitions of personalisation as they appear in literature. Some definitions focus on personalisation as a capability of the company, whereas others (e.g. Peppers & Rogers, www.1to1.com; Riecken, 2000) define it in terms of its implementation in marketing execution. However, the majority of the definitions define personalisation as the process of adjusting the marketing offerings (products, services, or information) to the identified needs of customers.

Table 2.1. Definitions of personalisation (adapted from Vesanen & Raulas (2006) and Adomivicius & Tuzhilin (2005))

Allen, Kania, & Yaeckel (2001)	Company-driven individualisation of customer Web experience.
Bonnett (2001)	A process of gathering user information during interaction with the user, which is then used to provide appropriate assistance or services, tailor-made to the user's needs.
Cöner (2003)	Performed by the company and based on a match of categorised content to profiled users.
Dyché (2002)	The capability to customise customer communication based on knowledge preferences and behaviours at the time of interaction with the customer.
Hagen (1999)	The ability to provide content and services tailored to individuals based on knowledge about their preferences and behaviour.
Hanson (2000)	A specialised form of product differentiation in which a solution is tailored to a specific individual.
Imhoff, Loftis, & Geiger (2001)	The ability of a company to recognise and treat its customers as individuals through personal messaging, targeted banner ads, special offers on bills, or other personal transactions.
Peppers & Rogers (www.1to1.com)	One-to-one marketing based on the idea of an enterprise knowing its customer. Through interactions with a customer, the enterprise can learn how a customer wants to be treated and can then treat that customer differently from other customers.
Personalization Consortium (2005)	The use of technology and consumer information to tailor electronic commerce interactions between a business and each individual customer. Using information either previously obtained or provided in real time about the customer, the exchange between the parties is altered to fit that customer's stated needs, as well as the need perceived by the business based on the available customer information.
Peppers & Rogers (1997)	The process of using a customer's information to deliver a targeted solution to that consumer is known as personalisation or one-to-one marketing.
Peppers, Rogers, & Dorf (1999)	Customising some feature of a product or service so that the customer enjoys more convenience, lower cost and some other benefit.
Riecken (2000)	Building customer loyalty by building a meaningful one-to-one relationship; by understanding the needs of each individual and helping satisfy a goal that efficiently and knowledgeably addresses each individual's needs in a given context.
Riemer & Totz (2003)	To match one object's nature to one subject's needs. More precisely: to customise products, services, content, communication etc. to the needs of single consumers or customer groups.
Roberts (2003)	The process of preparing and individualising communication for a specific person based on stated or implied preferences.
Wind & Rangaswamy (2001)	Either initiated by the customer (i.e. customising the look and contents of a website) or by the firm (i.e. individualised offering, greeting customer by name).

Several key elements can be identified from the variety of definitions (Adomavicius & Tuzhilin, 2005). Summarising, personalisation involves:

1. Tailoring certain offerings
   - such as information (e.g. WebPages), services, personalised product and service recommendations (e.g. books, CDs, and vacations), and e-commerce interactions
2. made available by a certain provider
   - such as e-commerce web-sites, or a food company
3. to the needs of their customers
   - such as consumers or website clientele

4. based on knowledge about those customers
   - which may be explicit or implicit knowledge, preferences, or behaviours
5. through an iterative process
   - in which the customer often directly or indirectly acts as co-designer
6. with certain profit goal(s) in mind
   - which can be simple (improving browsing and shopping experience, such as by presenting only content relevant to the consumer) to much more complex (e.g. building long-term relationships with the customer).

Personalisation thus requires knowledge about the consumer and his/her specific needs, and adjusting offerings to fit those needs. Some offerings, such as services (which are by nature often developed in interaction with the consumer) and information can be adjusted to consumer needs relatively easily. However, to adjust physical products to individual consumer needs entails substantially increasing the complexity of the supply chain, with potential additional costs as a consequence. This is the field of customisation.

Sometimes referred to as "product personalisation" (Riemer & Totz, 2003), mass customisation is the field of research that focuses on using flexible manufacturing processes to customise physical products to the needs and preferences of consumers with mass production (or near mass production) efficiency (Piller & Müller, 2004). Personalisation and mass customisation are different but closely related terms. Wind and Rangaswamy (2001) differentiate between the two terms, arguing that personalisation is the process located on the consumer side of the marketing spectrum, whereas mass customisation is the process on the operational product side. Much of the mass customisation literature originates from the literature on flexible manufacturing. In customisation, consumers can alter or even create products that contain precisely those attributes that the individual consumer specifies (Godek, 2002). In other words, the marketing offerings are being adjusted by or for the user very close to the moment of purchase or consumption. An example would be companies like Dell and Gateway, which adopt flexible and responsive manufacturing systems that create products to meet the needs of individual consumers upon their request (Pine, 1993). In contrast, personalisation does not presuppose on-the-spot personalised production. Usually based on directly elicited or indirectly inferred consumer preferences, the firm recommends those products from an existing range that provides the best fit with those preferences (Godek, Yates, & Yoon, 2002). An example of personalisation would be Amazon.com, which recommends alternatives on the basis of consumer-expressed preferences ("customers who bought this item also bought…"). In conclusion, customisation goes one step beyond personalisation, in that the customer is an active co-designer of the product (Bonnett, 2001). Mass customisation in the context of nutrition involves a large number of complex supply chain issues that are beyond the scope of this chapter.

Personalisation implies an interaction between the customer and the supply chain. Simonson (2005) discusses this interactive process and emphasises that customer satisfaction is not only enhanced through delivering products with superior fit to the customer's individual preferences, but also that through self-assessment, the interactive process itself can help shape the customer preferences, particularly when customers do not yet have stable preferences. In this way, personalisation may be a means to offer customers what they want, often even before they know that they want it (i.e. latent needs). Others (Fotheringham & Owen, 2000) have argued that although interaction is important, personalisation is not restricted to synchronous interaction. Personalisation may be based on previously collected consumer information. Also, personalisation issues are dominant in – but not restricted to – online interactions (Murthi & Sarkar, 2003) but can be realised at all user interfaces (Riecken, 2000).

Process models for personalisation

In the personalisation literature (see Table 2.2), process models have been proposed that describe personalisation as a number of consecutive and inter-linked steps (Vesanen & Raulas, 2006). These models differ, depending on the specific fields they originate from, and tend to be biased toward the marketing side rather than the consumer evaluation side of the personalisation process. Several authors (Piller, 2005; Steckel et al., 2005) have argued for more research on consumer evaluation, as successful personalisation depends on an enduring learning relationship between the customer and the firm. Hence, the existing process models as included in Table 2.2 should be conceived of as cycles rather than linear processes, with their success depending on the ability to generate repeated interaction with the customer.

Process models by Murthi and Sarkar (2003) and Adomavicius and Tuzhilin (2005) separate the personalisation process into three stages: (1) understanding and learning about customers' preferences, (2) delivering personalised offerings to customers, and (3) evaluating the learning and matching process. Pierrakos et al. (2003) describe the personalisation process in four basic features, namely: (a) the two-way nature of the communication system, (b) the level of response control that each party has in the communication process, (c) the personalisation in the communication process, and (d) the use and involvement of database technology. However, the specific tasks they distinguish in the personalisation process again relate to the understanding (data collection), personalisation (data pre-processing, pattern discovery, knowledge post-processing) and evaluation (reports) sub-stages.

Vesanen and Raulas (2006) synthesise these process models by distinguishing between four *objects* (customer, customer data, customer profile and marketing output) and four *operations* (interactions, processing of information, customisation and delivery) as the key variables that together define the marketing process with individual consumers.

Table 2.2. Several process models for personalisation, as summarised in Vesanen and Raulas (2006)

Adomavicius and Tuzhilin (2005)	Murthi and Sarkar (2003)	Pierrakos et al. (2003)	Vesanen and Raulas (2006)
Understand the consumer o collect data o create consumer profiles	Learn about consumer preferences	Collect data	Interaction with customer Customer data
Deliver personalised offering o matching o delivery and presentation	Match offerings to customers	Pre-process data Discover patterns Post-process knowledge Personalisation	Process information Customer profile Customisation Marketing output Delivery
Measure impact of personalisation o adjust personalisation strategy	Evaluate the learning and matching processes	Reports	Interaction with customer Customer data Process information Customer profile

The Vesanen and Raulas (2006) model defines the personalisation process as a loop, with the customer as the starting point. Through interactions with a customer, relevant data are collected, such as expressed preferences (e.g. through questionnaires), website/purchasing behaviour, or other more objective measurements such as blood parameters and genetic typing. This customer information is processed into relevant customer profiles that serve as a basis for the differentiation and segmentation of customers. Sophisticated techniques such as data-mining and neural networks are increasingly being used for this purpose. The customer profiles are used to generate personalised marketing output, such as tailored communication material, personal advice, or personalised products. The delivery stage describes how (e.g. through which channel) the personalised marketing offerings reach the customer and will bring about a response from the customer as a new interaction, resulting in new customer data. This closes the loop in the Vesanen and Raulas (2006) model, as this new customer information will be processed into customer profiles as a new input into the customisation process.

At a more general level, the proposed stages can be classified in terms of three responsibility domains: (1) consumer, (2) consumer-firm interaction, and (3) firm. The consumer domain refers to those stages that involve consumer actions, whereas the consumer-firm interaction domain comprises the processes by which the supply chain and the consumer interact through various interfaces. Finally, the firm domain includes the value-creation process undertaken by the supply chain on the basis of the consumer's personal information.

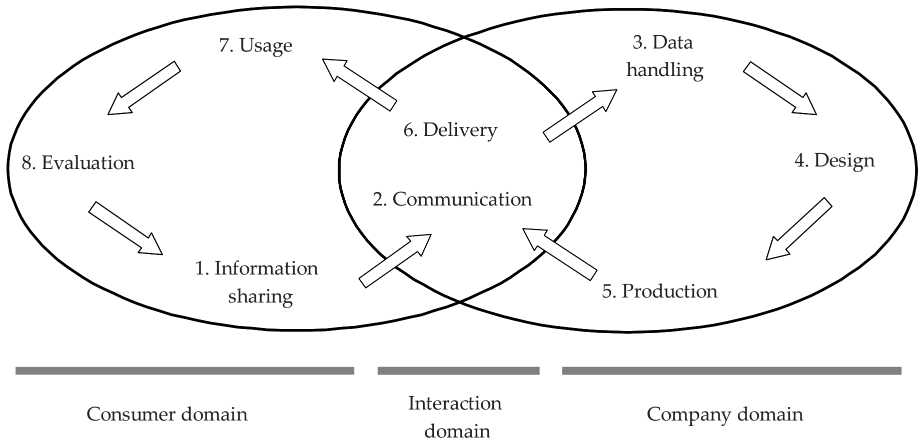

Figure 2.1. The structure of personalised recommendation systems

Ronteltap et al. (2006) have developed a process model specifically for the area of personalised nutrition, which defines specific stages in each of the three responsibility domains within the personalisation process: the consumer, the interaction, and the firm. The model (see Figure 2.1) describes the personalisation process in 8 different stages (see also Steckel et al., 2005; Wendel, 2007). During the first stage of the exchange process, consumers make available certain personal and possibly sensitive information (e.g., current health condition) to the supply chain (*stage one: information sharing*). In the next stage, this information passes through a physical interface (e.g., service desk), a digital interface (e.g., electronic questionnaires), or a combination (*stage two: communication*). *Stage three* of the exchange process (*data handling*) pertains to the receiver of the information (i.e., the supply chain) that will transform the personal information into a personalised solution on the basis of a decision model (*stage four: design*). Subsequently, the supply chain will create or select personalised recommendations (information and/or lifestyle or product advice) that address the needs of a particular client (*stage five: production*). In *stage six* (*delivery*), this personalised advice, involving different types of information possibly combined with products or services, is communicated and/or distributed via a user interface (e.g. e-mail) and received by the consumer. After acting upon the recommendation (*stage seven: usage*), the consumer may evaluate the added value of the recommendations and assess any personal benefit obtained from the interaction (*stage eight: evaluation*). This evaluation will then serve as input to the next cycle and the decision about whether or not to repeat the interaction.

By emphasising the three domains, the model illustrates the joint responsibility of the consumer and the firm in establishing the personalised interaction. Whether such interactions occur depends largely on the perceived costs and benefits from the personalisation process, which we will review next. Subsequently, we will specifically focus on the consumer evaluation of personalised nutrition.

Costs and benefits involved in personalisation

To assess the marketing feasibility of personalisation requires an analysis of the perceived costs and benefits for the actors in the personalisation process. Some authors (e.g. Piller & Müller, 2004) argue that from a marketing perspective, the consumer decision to engage in personalised advice (on nutrition or another matter) is basically the result of a simple equation: "if the (expected) returns exceed the (expected) costs, the likelihood that customers will engage in this option will increase." The decision of suppliers to provide personalised advice follows the same logic: only if the expected returns exceed the expected cost will the firm offer personalised advice. The costs to the company are the costs of collecting personalised consumer information and differentiation (e.g. delivering personalised advice and the costs of resources required to do so). The returns are the price premium that can be charged for individualised options, the relationship and customer loyalty that individualisation may build, and the enhancement of corporate or brand image. The key question is how to define the costs and returns at the consumer level. Whereas the firm's costs and benefits can be expressed in monetary units, the consumer value is more complex and involves psychological and ethical factors, too (Karat, Brodie, Karat, Vergo, & Alpert, 2003). At the consumer level, costs and benefits are usually (e.g. Karat et al., 2003; Piller & Müller, 2004; Simonson, 2005) differentiated into those emerging from the outcomes of the personalisation process and those emerging from the interactive process itself.

Consumer costs and benefits at the outcome level. Consumer benefits of personalised offerings arise from the increased utility of products and services that better fit personal needs compared to the best standard option attainable. In terms of personalised nutrition, the benefits would be represented by the added contribution to personal health and the simplification of the choice process. Provided that the information is simple and trustworthy, personalised advice can reduce confusion and the costs of sifting through the amount of nutrition information available. The costs factor would constitute the costs of what the consumer would have to compromise in terms of taste and convenience value and the price premium the consumer would have to pay for personalised offerings compared to standard offerings (Piller & Müller, 2004).

Consumer costs and benefits at the interactive process level are much more diverse and are often psychological rather than economic in nature. Consumers may derive value from co-designing the marketing offerings (Piller & Müller, 2004), i.e. being totally immersed in the interaction process itself (Csikszentmilhalyi, 1990), successfully fulfilling the co-design task (Dellaert & Stremersch, 2005; Franke & Piller, 2004), and appreciating the presentation format or context (Simonson, 2005). Consumers may also experience symbolic benefits from the process of co-design, such as pride of authorship, sheer enjoyment, and a sense of creativity in task accomplishment (Piller, 2005). The interactive process itself can help consumers construct their preferences, adding to a sense of self-knowledge (Simonson, 2005). Further, personalisation in nutritional advice can facilitate the empowerment of the individual consumer (e.g. Bouwman et al., 2005) in terms of access to information, improved decision-making, and ultimately to "exercise control over genetic destiny" (Chadwick, 2004).

However, the interactive process also involves perceived costs on the part of the consumer. These costs primarily constitute the cost of disclosing personal information (Karat et al., 2003); here, privacy issues become pertinent. This is particularly problematic in the case of genetic information, as the information is hard-wired and stable over time, may be relevant to many different parties (e.g. insurance companies), and it is uncertain what applications the information may have in the future (Chadwick, 2004). As a result, consumers may be reluctant to accede to their genetic information being stored, as in the future it may be used against their own best interest (Chadwick, 2004). As a psychological cost, consumers may experience a lack of freedom and invasion of marketers into their personal preferences; or they may interpret personalisation as attempts to persuade and manipulate (Simonson, 2005). Also, the active involvement in the co-design task may result in the consumer feeling psychologically at a disadvantage, because the manufacturer possesses much more information. The consumer has few options available, other than trusting that the manufacturer will propose the best personalised option.

Value to the company can be expressed in terms of the costs and benefits associated with the gathering of personal information from customers and the costs and benefits obtained from marketing personal solutions (Karat et al., 2003). Piller and Müller (2004) distinguish between the differentiation, cost, and relationship aspects of personalisation. Offering products and services tailored exactly to the customer's needs gives the firm a competitive advantage, takes the offerings out of the commodity offerings, and, if recognised by customers, may generate consumer preference for these differentiated offerings. The cost aspect of personalisation depends on the extra costs the firm incurs in the production and marketing of personalised solutions in relation to the price premium that can be charged for the personalised offerings. The relationship aspect of personalisation and customisation arises from a customer bonding with the company and the increase in customer loyalty arising from that (Simonson, 2005). Importantly also, this enduring learning relationship with the customer may result in specific information that is often hard to capture by conventional methods of market research. Building on this difficult to obtain information may in turn deter competitors.

Riemer and Totz (2003) elaborate on the company's economic motivation of personalisation in relation to customer retention, which may be the result of the consumer's technological (e.g. incompatibility of technological systems), contractual (contract periods), or psychological obligations (e.g. brand preferences caused by satisfaction) to the company. Each of these obligations constitutes a so-called 'lock-in' effect, caused by switching costs, which – from a customer perspective – are defined as any cost associated with the migration to a new supplier, vendor, or service provider. The costs of switching customer relationships can be subdivided into direct switching costs, opportunity costs, and sunk costs. Consumers experience direct switching costs because they find it more difficult to compare personalised products from rival companies and because personalised products increase their emotional obligations to the firm. Once a customer has entered into a relationship on the basis of personalised information, he or she is confronted with direct switching costs, and with opportunity costs associated with the probability of losing the advantageous effects of the current relationships. Finally, sunk costs (although economically irrelevant) associated with consumers' irreversible prior investments in establishing the current relationship are likely to reduce consumers' willingness to invest in a new relationship (Riemer & Totz, 2003). As a result, successful personalised relationships based on trust in the supplier "might drive customer satisfaction, trust and investment and increase switching costs – preventing customers from defecting" (Riemer & Totz, 2003, pp. 38-39).

Consumer evaluation of personalisation

As identified earlier, an area less well understood (Piller, 2005; Piller & Müller, 2004; Steckel et al., 2005) is how consumers evaluate and choose consumer-firm interaction mechanisms as complex as those in personalised nutrition. Two fields of research that may be informative here are the technology acceptance model (e.g. Davis, Bagozzi, & Warshaw, 1989) and the self-service technology acceptance model (e.g. Dabholkar & Bagozzi, 2002), both building on Rogers' seminal work on the adoption and diffusion of technological innovations. Rogers' (2003) diffusion of innovations theory states that the speed of adoption of innovations can be partly explained by consumer characteristics (such as innovativeness) and the perceived characteristics of the innovation: (1) relative advantage to the user, (2) compatibility with existing habits and values, (3) perceived complexity of the innovation, (4) ability to try out the innovation on a small scale, and (5) the visibility of results of applying the innovation. Rogers' theory has enjoyed wide application in the marketing and innovation literature. In a meta-analysis of applications, Tornatzky and Klein (1982) show that three of the perceived innovation characteristics (relative advantage, complexity, and compatibility) are indeed consistently related to adoption (see also Meuter, Bitner, Ostrom, & Brown, 2005). The research tradition on consumer adoption of information technology in the working place has subsequently emphasised the so-called Technology Acceptance Model (Davis, 1989; Venkatesh et al., 2003) which posits that ease of use and perceived usefulness are the key determinants of adoption of information technology. The model has also been applied in consumer adoption of self-services in the supermarket environment (e.g. Dabholkar & Bagozzi, 2002), where it has been shown that perceived enjoyment in using the system adds to predictive validity of the adoption models over and above ease of use and usefulness.

In a first systematic study on consumer evaluation of personalised nutrition systems, Wendel (2007) extended the Technology Acceptance Model with consumer perceptions of privacy or safety (see Figure 2.1). They showed that usefulness, enjoyment, and privacy protection are the key perceived benefits on which consumers base their evaluation of personalised recommendation systems, together accounting for 80% of the variance in consumer preferences. They also show that these perceptions of benefits almost completely mediate the effects of personalised nutrition features on consumer preferences. It thus seems that variants of the Technology Acceptance Model are useful for understanding consumer evaluations of personalised nutrition, with usefulness, enjoyment, and privacy protection as key benefits.

Operational dimensions of personalised nutrition

To our knowledge, no studies to date have elicited consumer responses to different operationalisations of the personalised nutrition process. In this section we will summarise the results from a study on this issue that also appeared in the thesis of Wendel (2007, pp. 55-81). This study is an empirical test of the model shown in Figure 2.1. Each stage of the model was operationalised at three levels (see Table 2.3). Based on these levels, systematically varied scenarios were developed as different combinations of levels of each of the eight stages (see Figure 2.1). These scenarios (see box 2.1 for an example) were then evaluated by consumers in a scenario-rating task. Consumer evaluation measures included the perceived benefits ease of use, usefulness, privacy protection, and enjoyment, and the willingness to use the system. As the study has been reported elsewhere in detail, only the main results will be discussed here. The study confirms that:

- the personalisation process can indeed be conceived of as consisting of three domains: a consumer domain, an interactive domain, and a firm domain;
- efforts in each of these domains contribute to overall consumer evaluation;
- each of the eight stages of the personalisation process (see Figure 2.1) contributes to the overall evaluation of personalised nutrition offerings, lending support to the personalisation process model;
- what consumers are most suspicious of are commercial applications in terms of the type of offerings (i.e. branded food products), the ownership of the database technology (to translate the consumer profile into a personalised diet), the sharing of personal

information with commercial companies, and the route to interaction (e.g. through fitness clubs);

- consumers prefer to receive personalised nutritional advice through established health institutions, particularly the family practitioner;
- consumers prefer to be able to choose the specificity of nutritional advice (preferring advice at the level of ingredients and product groups, rather than about specific brands and products) and optional (rather than mandatory or no) feedback;
- consumers prefer solutions that they can easily incorporate into their daily lives;
- the effects of design features on consumer attitude and intentions appear fully mediated by the perceptual dimensions of ease of use, usefulness, enjoyment, and privacy.

Table 2.3. Factors and factor levels applied in the scenario-rating tasks

1. Information sharing	5. Production
a. Blood composition	a. At ingredient level
b. DNA/genetic makeup	b. Food product groups
c. Food consumption habits	c. Special branded products
2. Communication	6. Delivery
a. Through fitness club	a. Through email
b. Through hospital	b. Through fitness club
c. Through family practitioner	c. Through family practitioner
3. Data handling	7. Usage
a. Fully anonymous	a. Within existing meal patterns
b. Patient and family practitioner	b. Add special products to diet
c. Available to commercial food company	c. Prepare own adjusted meals
4. Design	8. Evaluation
a. Commercial company	a. No feedback for verification
b. Insurance company	b. Feedback for verification optional
c. Government Nutrition Center	c. Feedback for verification mandatory

Overall, the results as presented in box 2.1 show that there are still a number of hurdles to be overcome before personalised nutrition can be applied commercially in marketing. For example, the fact that people are very wary of commercial interests will make it difficult for food companies to apply genomics-based personalisation. Also, consumers rather provided information on food habits than on DNA, which would complicate the formation of genomics-based recommendations. In chapter 7, we will further discuss the critical success factors from a marketing point of view.

Box 2.1. Consumers' evaluation of alternative operationalisations of personalised nutrition. The most (*italics*) and least [in brackets] preferred scenarios

You go to your *family practitioner* [fitness club] to deliver *information on your food habits* [DNA information]. The personal information you provide will be to *known only to you and your family practitioner* [shared with commercial companies]. On the basis of your personal information, the *Nutrition Centre* [an insurance company] will compile personalised nutritional advice, which you will receive *through your family practitioner* [fitness club]. The personalised nutritional advice is in the form of *product groups* [branded food products] that you should eat more often or avoid. It is put together in such a way that *you can easily implement it in your regular diet* [you have to prepare separate meals, with special products]. After three months, you will probably already feel better, and this system *gives you the opportunity to verify* the improvements in your health status [does not provide feedback].

Conclusion

This chapter has developed a general framework for the stages involved in personalisation and consumer evaluation of personalised nutritional recommendations in particular. Built on marketing and consumer behaviour literature on personalisation, the framework takes a cost-benefit approach to personalised nutrition. As such, the evaluation of personalised nutritional advice is based on a trade-off between the perceived costs and benefits on the part of the consumer and the firm that interact in the personalisation process (i.e. an exchange of personal information against personalised solutions). We have argued that such personalised nutritional recommendations will only emerge if the benefits outweigh the costs in the process. We have also provided first evidence on how this would apply to genomics-based personalised nutrition.

This chapter has provided fundamental insights into personalisation; knowledge that is essential to understand the meaning and consequences of genomics-based personalisation in the food domain, central in the following empirical chapters. Furthermore, from this analysis of personalisation and personalised nutrition more specifically, it can be concluded that the consumer perspective on personalisation is an under-researched area that deserves more attention.

3

CONSUMER ACCEPTANCE OF TECHNOLOGY-BASED FOOD INNOVATIONS

Lessons for the future of nutrigenomics

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Introduction

Scientific and technological innovations have contributed greatly to various domains of man's quality of life, delivering both benefits to the individual consumer (e.g., personal computers) and society at large (e.g., food preservation). Many of these technology-based innovations (e.g., information technology) have been incorporated into daily life with high levels of consumer acceptance whereas others have met with substantial resistance (e.g., nuclear energy). Both within and external to the food domain, this has stimulated research to understand consumer acceptance of technology-based innovations. Such research is most prominent in the areas of information technology (Legris, Ingham, & Collerette, 2003), high-technology products (Ziamou & Ratneshwar, 2002) and service delivery (Meuter et al., 2005). Within the food area a similar picture emerges, with some recent technology-based innovations having been adopted easily and others essentially rejected by consumers (Cardello, 2003). Prominent examples of the latter are genetically modified foods (GMFs) in Europe (Gaskell et al., 2000) and food irradiation (Henson, 1995).

Consumer acceptance of technologies and technology-based innovations in food bears many similarities with that in other fields. However, they differ in at least one important respect, namely that novel foods are actually ingested by the consumer (Rozin, 1999). This may explain why consumer concerns and risk perceptions have received considerable attention in the literature on consumer acceptance of food innovations (Cardello, 2003; Miles & Frewer, 2001). There is, however, a need to understand consumer acceptance of food innovations in a broader context. For the specific area of food, learnings may be extracted from other areas where consumer acceptance has been studied extensively, such as information technology.

The aim of the present paper is to enrich the literature on consumer acceptance of technology-based food innovations with relevant insights from innovation research in other fields. We will selectively integrate the relevant insights that have not received due attention in the food area, into a more comprehensive conceptual framework for consumer acceptance of technology-based food innovations. Such broader insight is important not only for better understanding of consumer uptake of existing technologies. It can also provide a useful framework for the anticipation of future consumer acceptance of emerging food technologies, and provide a basis from which to identify potential barriers to consumer acceptance. We illustrate this application in the context of nutrigenomics.

Food technologies and innovations

Carayannis, Gonzalez, and Wetter (2003) distinguish between technology and innovation. Technology is the whole complex of knowledge, skills and equipment, often science-based, necessary to produce a product or service. These new products or services – applications available for the user – are considered to be *innovations*. For example, gene technology is the technology from which GMFs emerge as the innovation, and similarly for food irradiation and irradiated foods. Although it is useful to make a distinction between the two concepts, they cannot be seen separately from each other. Lam and Parasuraman (2005) operationalise technology acceptance as the initial acquisition of a technology-based product or subscription to a technology-based service. This implies that much of the insight in technology acceptance is derived from consumer acceptance of its applications (innovations), although some studies focus on consumer acceptance of technologies per se. We appreciate that technologies and innovations emerging from them are not always strictly separable, neither in definition, in daily use of the terminology nor in research applications (see, for example, Bredahl, 2001). The scope of this paper is consumer acceptance of technology-based innovations in particular. For reasons of conciseness, from this point onwards we will use the term 'innovation' to indicate this specific type of innovations.

In the area of food and nutrition, various technological applications, which have resulted in novel foods, have emerged in the past decades. Many of these were related to prolonging the shelf life of foods and enhancing their safety, e.g., pasteurisation, and novel food packaging. A food preservation technology that has failed to reach widespread adoption is food irradiation. Despite the fact that the scientific community recognised food irradiation as a safe and effective process, significant consumer resistance has inhibited the application of the technology (Henson, 1995). In the 1990s, the genetic modification of foods also met with great consumer scepticism (Bredahl, 2001; Sparks, Shepherd, & Frewer, 1994). In recent years, many of the new food technologies and food innovations have been targeted at the promotion of good health. Fortification and restoration of foods were used as methods to add nutrients to food products that did not contain them originally or had lost them in the manufacturing process. Functional foods constitute a range of novel foods designed to deliver benefits beyond nutritional value to the person consuming them (Frewer, Scholderer, & Lambert, 2003), and the so-called nutraceuticals provide medical or health benefits by maintaining and modifying bodily functions (Hardy, 2000). These previous developments have all entered the marketplace at time of writing. Some are widely used and others are less successful from a consumer acceptance perspective.

Nutrigenomics is an emerging technology in the health maintenance and promotion area. Its area of innovation is represented by personalised food products and services. Nutrigenomics is a sub-area within the field of genomics, which is a relatively new term indicating research into the functioning of the genome. Nutrigenomics has been defined as 'understanding how nutrition influences metabolism and maintenance of the internal equilibrium in the body, how this regulation is disturbed in the early phase of a diet-related disease, and to what extent the individual genotype contributes to such diseases' (Müller & Kersten, 2003). In other words, the technology of nutrigenomics focuses on developing an improved understanding of the relationship between human nutrition and human genetics in order to maintain and promote health and prevent the occurrence of disease. The innovative feature of nutrigenomics in nutritional sciences is that it is based on knowledge of the individual's genetic constitution. This information is used to explain the effect of specific nutrients on human physiology and even idiosyncratic responses to food intake[1]. Besides advancing the fundamental understanding of diet-disease relationships, nutrigenomics may have another important spin-off. It could provide opportunities for the development of food products or dietary advice tailored to the nutritional needs of specific groups of consumers, or even individuals. Some authors have optimistically argued that these so called 'personalised foods' will shift the food market from a technology push into a consumer pull system, where innovation development is determined by the demand side of the market. In that situation, the consumer's preference for optimal health is a major driver for food choice, and as a consequence for how foods are produced (German, Yeretzian, & Watzke, 2004).

Despite its promise, nutrigenomics may also raise consumer concerns regarding the impact of human genetics on the integrity of nature, privacy and control over sensitive information. In a Canadian research project, genomics research related to food evoked strong associations with genetic modification of crops and foods, e.g., Golden Rice (Burgess, 2003). Such associations are inevitable and deserve substantial attention and a careful management of expectations, concerns and promises of the potential deliverables of nutrigenomics.

The inherent newness of the emerging science and the likely ambivalence in consumer attitudes towards nutrigenomics make it a particularly appropriate case to illustrate the framework we develop as a conceptual tool for anticipating future consumer acceptance. The framework will be based on a review of studies addressing consumer acceptance of technology and innovations in the food area including GMFs (e.g. Frewer, 2003; Saba & Vassallo, 2002; Siegrist, 2000), and functional foods (Childs & Poryzees, 1998; Frewer, Scholderer et al., 2003; Schmidt, 2000) and extend beyond these to include relevant findings from other domains (such as information technology).

In summary, the aim of this paper is twofold. First, we develop a comprehensive conceptual framework for consumer acceptance of food innovations, based on an integration of food-related literature enriched with relevant findings from other domains. Second, the newly developed conceptual framework is illustrated as a structuring tool to identify the potential critical success and failure factors for the emerging science of nutrigenomics and personalised nutrition.

[1] Note that nutrigenomics does not involve the genetic manipulation of food products. This is the field of gene technology that should be distinguished from nutrigenomics.

Conceptual framework development

Consumer acceptance of innovations has been studied from various disciplines and theoretical perspectives. A rough distinction can be made between research at the (macro-) level of society, for example, by sociologists and economists, and at the (micro-) level of individual consumer behaviours, for example, by psychologists and researchers of perceived risk.

Perceived cost/benefit considerations

From a traditional economic point of view, the acceptance of technological developments in society has been approached as an economic cost/benefit analysis, where a trade-off is made between societal benefits and economic costs associated with a certain technology or activity (Starr, 1969). For example, in the economic cost approach of Starr, risk was measured as the probability of fatalities per hour of exposure of the individual to the hazard under consideration, and the benefits were represented in terms of the monetary value of the average annual benefit per person involved. Obtaining maximum social benefit at minimum social cost would be the ultimate goal of this trade-off. Although an elaborate discussion of this economic research area is beyond the scope of this review, the main contribution lies in its focus on the trade-off between costs and benefits inherent in the innovation as a determinant of consumer acceptance of innovations.

The trade-off between individual costs and benefits of an innovation is also a critical element in Rogers' diffusion of innovation theory (Rogers, 2003) and attitudinal models of innovation acceptance, where this trade-off may contribute to the relevant attitudes that consumers hold to the innovation, and which may determine acceptance or rejection (Frewer, 2003). Often, such personal considerations of cost benefit trade-offs are the more important determinant of actual behaviour (Klandermans, 1992).

Diffusion of innovations

The study of diffusion of innovations has a long history in sociology and can be largely traced back to an early study on the diffusion of hybrid seed corn among Iowa farmers (Ryan & Gross, 1943). This study revealed that the rate of adoption of the agricultural innovation followed an S-shaped curve when plotted against time. Innovations primarily differ in the slope of the curve: the rate at which larger groups of consumers begin to accept the innovation. Rogers (1995; Rogers, 2003) has made a major contribution in popularising these original findings and extending on them to develop a more comprehensive theory on diffusion of innovations, which has been a fruitful source for a wide spectrum of applications (see Tornatzky and Klein (1982) for a meta-analysis).

Rogers' theory defines *diffusion* as the process by which an innovation disseminates over time among the members of a social system (Rogers, 2003, p. 5). His theory builds on four cornerstones, namely the identification of adopter categories, communication, the individual innovation-decision process and the identification of important characteristics of an innovation. Individuals can meaningfully be classified in terms of the relative speed at which they adopt innovations. Following a standard normal distribution curve, the *adopter categories* are defined as (1) innovators, (2) early adopters, (3) early majority, (4) late majority, and (5) laggards (Rogers, 2003, p. 22). *Communication* is a crucial process through which individuals become aware and knowledgeable about different innovations. The *innovation-decision process* is the mental process through which an individual passes from (1) initial knowledge of an innovation to (2) forming an attitude toward the innovation, to (3) a decision to adopt or reject it, to (4) implementation of the new idea, and to (5) confirmation of this decision. In this process the individual obtains information in order to gradually decrease uncertainty about the expected consequences of the innovation. Individuals vary in the time it takes them to go through the different stages. For the purpose of anticipating consumer reactions to innovations, a particularly relevant finding from Rogers' research is the identification of five *characteristics of innovations* that help explain the differences in adoption rates. These are:

1. *Relative advantage*: i.e. delivering a certain advantage over preceding technologies or methods, be it in terms of economics, convenience, social prestige or satisfaction.
2. *Compatibility*: or fitting in with existing values, past experiences and needs of potential adopters.
3. *Complexity*: an innovations' ease of use will lead to rapid adoption.
4. *Trialability*: potential adopters want the availability of experimenting with an innovation on a limited basis before adopting.
5. *Observability*: the results of an innovation should be easily observed and communicated to others.

To summarise, Rogers' theory states that the likelihood of a particular individual adopting a specific innovation is a function of characteristics of the innovation itself, characteristics of the potential adoptee, and the information, which accompanies the innovation (both in terms of *content* and the *amount* of information provided). Rogers' model is defined at a fairly general level, which makes it widely applicable, but does not allow it to provide very detailed information in specific cases of innovations. To our knowledge it has not been extensively applied in the area of acceptance of food technologies and innovations.

Attitudinal models

In *psychology*, the attitudinal models of Fishbein and Ajzen have been widely applied to explain adoption of innovations. As an extension of the Theory of Reasoned Action (TRA), the Theory of Planned Behaviour specifies Perceived Behavioural Control (whether the person thinks he or she can actually perform the behaviour) as a determinant of behaviour and behavioural intention, together with social norm (i.e. whether significant others are likely to endorse the use of the innovation or activity) and attitude (i.e. the extent to which an individual is positive about engaging in the behaviour under consideration) (Ajzen, 1991). Attitude models have found wide application in explaining consumer adoption and diffusion of information systems (particularly in the work place). Building on Rogers and as an extension of the TRA, Davis (1989) developed the popular Technology Acceptance Model (TAM). This model replaces many of TRA's attitude measures with two technology acceptance measures: ease of use, and usefulness, which represent Rogers' dimensions of complexity and relative advantage respectively and have been confirmed in many studies (see Lee et al., 2003).

Attempts have been made to combine and integrate different theories of consumer acceptance of innovations to enhance predictive ability (Lee et al., 2003). For example, from an integration of TAM and seven competing models, Venkatesh, Morris, Davis, and Davis (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) with superior predictive ability. UTAUT includes four key determinants (performance expectancy, effort expectancy, social influence and facilitating conditions) and up to four moderators of key relationships (gender, age, experience and voluntariness of use). This work shows that integration of existing models can lead to a better understanding of consumer behaviour in the context of adoption of innovations.

Perception of risk and uncertainty

Perceptions of risk and uncertainty have been shown to play an important role in the acceptance of food innovations (Cardello, 2003; Frewer, Miles, & Marsh, 2002). The widespread research attention for understanding consumer concerns about new technologies (e.g. Cardello, 2003) is not surprising given the intimate relationship consumers have with foods which are actually ingested into the human system (Rozin, 1999). In addition, food technologies typically possess many of the risk characteristics that engender greatest concern among consumers (Cardello, 2003). Among these are whether new technologies are perceived to be largely involuntary, unobservable, out of control by the consumer and may have unknown, delayed and potentially fatal health effects (in the eyes of some consumers) (Slovic, 1987). Indeed, food technologies are often associated with so-called credence qualities (Darby & Karni, 1973), the costs and benefits of which cannot be unambiguously verified by the individual consumer from personal experience, such as safety, sustainability, health, and naturalness. These credence qualities are particularly prone to generate perceived risk and uncertainty, particularly when information is inconsistent and trust in authorities is low. Trust in risk regulators and managers plays an important role in public risk perceptions and has been found to be hard to acquire and easy to lose (Frewer & Salter, 2002; Slovic, 1999).

Psychometric studies into consumer associations with a broad range of hazards (e.g. Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Sparks & Shepherd, 1994) reveal that consumer concerns with new technologies centre around the dimensions of *dreadedness* and *the extent to which a hazard is judged to be unknown*, the former being the most important. The higher a particular hazard rates on these two dimensions, the higher its perceived risk, the more people want to see its current risk reduced, and the more they want to see strict regulation to reduce the risk (Slovic, 1987). A study by Miles and Frewer (2001) confirms that consumer concerns regarding food hazards are important determinants of acceptance, and some concerns (for example, health concern) were common to all hazards included in the study.

Consumers perceive a hazard as riskier when they also perceive that the consequences of the hazard are highly unknown to scientific experts (e.g. Slovic, 1987). Scientific uncertainty about the potential advantages and disadvantages of a technological innovation, and the way these are being communicated to the public, can have a major impact on its consumer acceptance (see, for example, Frewer, Howard, & Shepherd, 1998), particularly under circumstances whereby the public perceive that the uncertainty is being 'hidden' by regulatory institutions (van Kleef et al., 2006).

Uncertainty exists when details of situations are ambiguous, complex, unpredictable, or probabilistic; when information is unavailable or inconsistent; and when people feel insecure about their own knowledge or the state of knowledge in general. It can trigger uncertainty management strategies on the part of the consumer, such as seeking or avoiding information to manipulate uncertainty in the desired direction (Brashers, 2001). The degree of uncertainty basically determines whether a negative aspect of a technological innovation is categorised as a cost or a risk.

Altogether, much work has been undertaken to model consumer adoption and societal diffusion of innovations in general and technology-based food innovations in particular. Together they incorporate many aspects of the consumer adoption process from awareness of the innovation to actual adoption. However, a comprehensive and systematic overview, which includes all potentially influential determinants is lacking. To fill this gap, we developed a conceptual framework for consumer acceptance of food innovations (Figure 3.1) that reflects state of the art thinking in food research augmented with relevant findings from outside the food domain.

In our framework, consumers' actual adoption of innovation in the food area is ultimately determined by their intention to use it. The framework distinguishes between proximal and distal determinants of consumer adoptions. At the proximal level, adoption (intention) is determined by (1) perceived costs and benefits, (2) perceived risk and uncertainty, (3) subjective norm, and (4) perceived behavioural control. However, these perceptions are affected by a set of more distal determinants, namely (a) features of the innovation, (b) consumer characteristics, and (c) characteristics of the social system of which the consumer is part. Whereas innovation and consumer characteristics hold a direct relationship with perceptions of the proximal determinants, characteristics of the social system affect the framework more generically (see Figure 3.1)[2]. Communication is represented in our framework as an important means linking innovation features to consumer perceptions. We appreciate that this communication may need to be adjusted depending on the characteristics of the consumer (segment) at which the innovation is targeted.

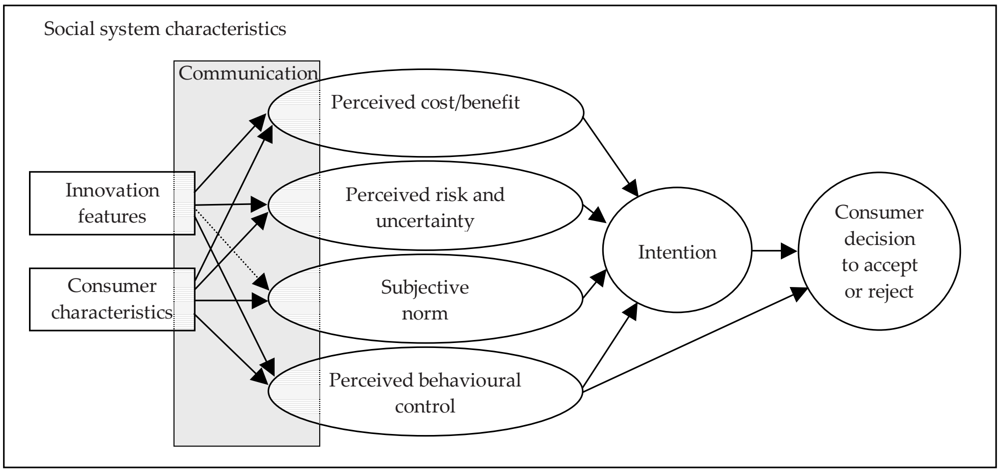

Figure 3.1. Conceptual framework for research on acceptance of technology-based food innovation

Our conceptual framework integrates various elements from the theories we have already discussed regarding consumer acceptance of food technologies and innovations. The framework utilises the attitude model as its basic structure, but extends it to include perceptions of risk and uncertainty. The attitude construct is more implicitly defined in terms of perceived costs and benefits, which includes the rational cost benefit considerations suggested in the economic literature. Rogers' innovation characteristics enter the framework at various places[3]. Relative advantage, compatibility, and complexity primarily relate to perceived cost-benefit, whereas trialability relates more strongly to perceived behavioural control. Observability relates more to social visibility, and hence the subjective norm dimension of the framework. Several studies (Grunert, Bech-Larsen, Lähteenmäki, Ueland, & Åström, 2004; Grunert, Bredahl, & Scholderer, 2003; Prislin, Wood, & Pool, 1998) have revealed that consumer attitudes and intentions toward specific objects can also be shaped by more general attitudes. These general attitudes held by consumers, together with their value structure and lifestyle factors, are contained in the framework as more enduring consumer

[2] Note that empirically, social system characteristics play a unique role as, compared to characteristics of the innovation and the consumer, they cannot easily be manipulated as an independent variable in empirical research.
[3] Note that in Rogers' model no strict distinction is made between objective characteristics of the innovation (features in our model) and consumer perception thereof (proximal variables in our model). Studies that focus on technology features, rather than consumer interpretations, will be classified in the technology feature part of our framework.

characteristics, which may shape their intentions through the proximal determinants in our model.

In summary, the main lines of thinking on consumer acceptance of food technology and the innovations emerging from it are integrated into this conceptual framework, which distinguishes between proximal and distal determinants of acceptance and recognises the important role of communication in linking distal to proximal determinants. In the following sections, we will review previous research on consumer acceptance of food technologies and food innovations against our framework and augment this with relevant findings from outside the food domain. Analysis of these studies is a complex task, because previous studies vary greatly in the abstraction level of the determinants that are being addressed. Also, across these studies we found almost as many measures of acceptance as there are researchers. Table 3.1 provides an overview of the studies (ordered alphabetically by first author) that are being reviewed in terms of basic characteristics of the study and how they fit into the proposed framework (Figure 3.1). The studies included in the review are selected on the criterion that they have relevant terms in keywords, title or abstract (e.g., consumer, acceptance, rejection, perception, risk, innovation, technology, food), and are published in leading journals (e.g., Journal of Marketing Research, Journal of Applied Social Psychology, Journal of Consumer Policy, Appetite, Food Quality and Preference, Trends in Food Science and Technology, Risk Analysis). Below we will discuss these studies in more detail in relation to our conceptual framework.

Previous empirical research into proximal determinants

The core of our framework is constituted by the four proximal constructs that influence consumers' attitude towards an innovation. We will use the structure of our conceptual framework for discussing these factors in the following section.

Perceived cost/benefit considerations

Benefit perceptions were reported as a determinant of consumer acceptance of innovations in the majority of reviewed literature. Of the 27 studies that identified perceived benefit as an influential factor, nine studies report an effect on actual behaviour, 10 on behavioural intention and another eight on attitude or related evaluative constructs. Actual adoption behaviour appears more often as the acceptance measure in high-technology research contexts such as information technology (Davis, 1989), where it is seemingly easier to explore adoption in real usage contexts than in food-related areas.

In cost-benefit-related determinants a distinction can be made between the benefits for the individual consumers, such as health benefits (Deliza, Rosenthal, & Silva, 2003; Magnusson & Koivisto-Hursti, 2002; Urala & Lähteenmäki, 2004), and benefits to society more

Table 3.1. Overview of the reviewed studies

Reference	Field of study	Distal determinants			Communication[a]	Proximal determinants				Acceptance measure
		IF	CC	SSC		PC/B[b]	PRU[c]	SN	PBC	
Bogue et al., 2005	Health-enhancing foods		X			B				Dietary behaviour
Bouyer et al., 2001	Broad range of hazards		X				G,J			*Risk perception*
Cardello, 2003	Food processing technologies		X		2					(Expected) product liking
Cestre & Darmon, 1998	Diffusion of wide range of new product	X	X							Consumer preference
Childs & Poryzees, 1998	Functional foods	X				B				Purchase interest
Choo et al., 2004	New processed food products in India		X					X		Intention to buy; Actual purchase behaviour; Attitude
Costa et al., 2000	GMF (vegetable oils)		X							Purchase intention
Cox et al., 2004	Functional foods, GM and dietary supplements								X	Intentions to consume functional foods
Dabholkar & Bagozzi, 2002	Technology-based self-service					C			X	Intention
Dahlberg et al., 2003	Mobile payment					C	K			Adoption
Davis, 1989	Information technology					C				Usage
Deliza et al., 1999	GMF (vegetable oils)	X								Purchase intention
Deliza et al., 2003	Non-conventional food-processing technology (high pressure)	X			2	B	H			Intention to purchase
Eiser et al., 2002	Food technologies (GM, irradiation, additives, pesticides)						G,K			Acceptance
Fam et al., 2004	Controversial products			X						Offensiveness
Finucane et al., 2000	Health and safety risks		X				G			*Risk perception*
Florkowski et al., 1998	New food production technologies		X				G			Support of technology
Fox et al., 2002	Food irradiation				2					Willingness-to-pay
Frewer et al., 1997	Food-processing technologies (cheese)	X				A,E,F				Purchase likelihood
Frewer et al., 1998	GMF		X		4					Attitude
Frewer et al., 1999	GMF				1,2					Attitude
Frewer et al., 2002	GMF				4	A	G,K			*Risk/benefit perception*
Frewer, Hunt et al., 2003	Food risks (from expert point of view)				4					Public distrust in science
Greer & Murtaza, 2003	Web personalisation					C			X	Acceptance
Griffin & Dunwoody, 2000	Lead in drinking water				2					Preventive behaviour adoption

Grunert et al. 2003	GMF		X							Attitude
Grunert et al., 2004	GMF		X							Attitude ⊚ Purchase intention
Honkanen & Verplanken, 2004	GMF		X							Attitude; Intention to buy
Karahanna & Straub, 1999	E-mail			X		C		X		System use
Kwon & Chidambaram, 2000	Cellular telephones		X			C		X		Use
Lähteenmäki et al., 2002	GMF (cheese)		X			D				Attitude ⊚ Intention to buy
Laros & Steenkamp, 2004	GMF				3		J			Attitude
Loureiro & Bugbee, 2005	GMF (tomato)	X	X			A				Willingness to pay
Magnusson & Koivisto-Hursti, 2002	GMF		X			B,E				Willingness to purchase
Moreau et al., 2001	Cameras and cars	X	X			A				Adoption
Palmer, 2003	Health and technological risks		X				G			*Risk perception*
Rimal et al., 2004	Irradiation (beef)	X	X		2					Purchase intentions; Actual purchase
Saba & Vassallo, 2002	GMF (tomato)		X			A		X	X	Intention to eat
Savadori et al., 2004	Biotechnology in food and medicine	X	X			A	G			*Risk perception*
Scholderer & Frewer, 2003	GMF				2	A				Attitude
Siegrist, 1998	Gene technology		X							Attitude
Siegrist, 2000	Gene technology		X			A	G,K			Consumer acceptance
Siegrist et al., 2000	Several risks			X		A	G			*Risk/benefit perception*
Stolt et al., 2002	Neonatal screening		X				I			Attitude
Tanaka, 2004a	Gene-recombinant technology		X			A	G			Attitude
Tanaka, 2004b	Nuclear power	X				A	G			Attitude
Tenbült et al., 2005	GMF					D				Acceptance
Titchener & Sapp, 2002	Biotech foods					F	H,K			Intent and willing to eat
Townsend & Campbell, 2004	GMF (apple)		X				G,J			Willingness to purchase
Tuorila et al., 2001	Unfamiliar foods		X							Willingness to try
Urala & Lähteenmäki, 2004	Functional foods		X		3	C				Willingness to use
Verdurme & Viaene, 2001	GMF		X			A	G,K			Attitude
Ziamou & Ratneshwar, 2002	High technology products				2		G			Adoption intention
Ziamou, 2002	Computer/ telecommunication						G			Adoption intention

Note: Abbreviations correspond to concepts in Figure 3.1: IF= Innovation Features, CC= Consumer Characteristics, SSC= Social System Characteristics, PC/B= Perceived Cost/ Benefit, PRU= Perceived Risk and Uncertainty, SN= Social Norm, PBC= Perceived Behavioural Control.

[a] *Sub-classification of communication: 1=source, 2=information, 3=consumer interest/confidence, 4=public discussion*

[b] *Sub-classification of perceived cost/benefit: A=C/B not specified, B=health-related C/B, C=usage-related C/B, D=sensory C/B, E=environmental C/B, F=production C/B*

[c] *Sub-classification of perceived risk and uncertainty: G=various types of risk, H=safety, I=concerns, J=feelings, K=trust*

broadly such as environmental benefits (Magnusson & Koivisto-Hursti, 2002; Titchener & Sapp, 2002). In addition, in some studies benefits are measured as a summary construct, e.g., by asking respondents: "Do you think this innovation is beneficial? (Tanaka, 2004a), while in most other studies benefits are measured at a more specific level such as in terms of sensory benefits (Lähteenmäki et al., 2002), or personal relevance (Frewer, Howard, Hedderley, & Shepherd, 1999). As to the type of costs and benefits studied in literature, several clusters can be identified; those related to elements of innovation usage, to sensory aspects, to health, to the environment, and to production. The sub-classification of the construct is represented in Table 3.1.

Outside the food domain, costs and benefits are often expressed in terms of Rogers' (2003) innovation characteristics usefulness (relative advantage) (Dahlberg, Mallat, & Öörni, 2003; Davis, 1989; Karahanna & Straub, 1999; Kwon & Chidambaram, 2000), compatibility (Greer & Murtaza, 2003), ease of use (complexity) (Dabholkar & Bagozzi, 2002; Dahlberg et al., 2003; Davis, 1989; Greer & Murtaza, 2003; Karahanna & Straub, 1999; Kwon & Chidambaram, 2000), and trialability (Greer & Murtaza, 2003), with ease of use and usefulness consistently reported as the strongest determinants of acceptance (Tornatzky & Klein, 1982).

Sensory attributes, especially appearance and taste, have always been important in the evaluations of food products (Grunert et al., 2003) and that is no different for technological innovations in food (Cardello, 2003). Several studies include sensory costs and benefits in their analysis of consumer acceptance of food innovations (Deliza, Rosenthal, & Silva, 2003; Rimal, McWatters, Hashim, & Fletcher, 2004). Lähteenmäki et al. (2002) showed that perceptions of the sensory qualities of GM cheeses would improve consumers' intentions to buy GM cheese. Consumer expectations of product quality in terms of sensory aspects and process characteristics are essential for new product success (Grunert, 2005). Expectations also play an important role in cost/benefit considerations regarding credence qualities delivery by the innovation such as the belief that food innovations would have disease-preventing ability, which was found to positively influence purchase interest (Childs & Poryzees, 1998).

Perceived reward from using functional foods, and perceived necessity for functional foods, were benefits found to predict willingness to use them by Urala and Lähteenmäki (2004). Over time, these beliefs may be stored in pre-existing overall evaluations that may affect future evaluations of specific innovations, as in the case of GM foods (e.g. Scholderer & Frewer, 2003).

In sum, there is considerable support from both food and non-food studies that perceived costs and benefits are a major determinant of consumer acceptance of food technology and innovations arising from it. Individual benefits, which have been more frequently studied in previous research, include usage- and health-related benefits. Among the costs and benefits at the societal level are included production benefits (e.g., increased food production), and necessity for society (e.g., by facilitating a healthy lifestyle). It is important to note that the perceptions of the consumer are not necessarily identical to the technical benefits and costs of an innovation as defined by its features.

Perceived risk and uncertainty

Risk and uncertainty appear in many published studies, which is not surprising (Cardello, 2003) as the actual qualities of innovations, and food innovations in particular, are often difficult or even impossible to estimate by consumers as they are either invisible, uncertain or only materialise in the long term. Therefore, consumer perceptions of risk and uncertainty associated with innovations play an important role for acceptance, especially in the context of life sciences. Interestingly, interactions between cost/benefit perceptions and risk perception can and do occur. For example, potential harm, potential benefit and risk perception were found to be interrelated in the context of several applications of biotechnology (Savadori et al., 2004).

Eleven out of 19 of the risk-related studies we reviewed measured risk as a summary construct and hence at a fairly general level. For example, Finucane, Slovic, Mertz, Flynn, and Satterfield (2000), used a four-category scale to measure the level of perceived risk of various activities and technologies. Others (e.g. Verdurme & Viaene, 2001) further differentiate between specified types of risk such as health and environmental risk perceptions. Studies outside the food domain frequently include perception of performance uncertainty (i.e. whether the innovation works as intended) as a determinant which was found to negatively affect consumers' intention to adopt high-technology products (Ziamou & Ratneshwar, 2002) and telecommunications (Ziamou, 2002).

Other studies focus on perceived safety for current human health or for the environment (Deliza et al., 2003; Titchener & Sapp, 2002), or to safety consequences for the future (Townsend & Campbell, 2004). Various consumer concerns, for example, those related to storage of sensitive information, or to the right to be informed about research results (Stolt, Liss, Svensson, & Ludvigsson, 2002) also influence consumer acceptance.

Feelings as a result of innovations have also been subject of study. Anxiety, for example, was shown to positively affect perceived risk across a broad range of hazards (Bouyer, Bagdassarian, Chaabanne, & Mullet, 2001). Laros and Steenkamp (2004) investigated the role of fear in the context of GMF. Consumers in their study felt more fear for GMF than for other types of food, more specifically functional foods, organic foods and regular foods. Feelings of dread about GM technology in food production reduced the willingness to purchase GM apples (Townsend & Campbell, 2004).

Another group of studies categorised under risk and uncertainty deals with the concept of trust. Trust in public health officials and scientists (Titchener & Sapp, 2002), in regulatory institutions (Frewer et al., 2002) and in food producers (Verdurme & Viaene, 2001) is beneficial for consumer acceptance of innovations, mostly studied within the field of biotech-foods. It has also been found that the acceptance of several other food technologies (GMF, irradiation, additives and pesticides) increased with higher levels of consumer trust (Eiser, Miles, & Frewer, 2002). Outside the food domain, it was found that an individual's disposition to trust (i.e. whether a person is inclined to have trust in general) indirectly increased adoption of mobile payment (Dahlberg, Mallat, & Öörni, 2003). A general disposition to trust is likely to influence many processes related to acceptance of innovations, also within the food domain.

In sum, several previous studies support the role of risk and uncertainty as a determinant of consumer acceptance of food innovations. The construct contains multiple aspects, namely safety issues, consumer concerns, emotions, and trust. Trust plays an important role in consumer acceptance as it reduces the perceptions of uncertainty and may reduce perceived risk.

Perceived behavioural control and subjective norm

Perceived behavioural control and subjective norm also affect consumer acceptance or rejection of innovations (e.g. A. J. Cook, Kerr, & Moore, 2002). Self-efficacy is a central concept in relation to perceived behavioural control, supported by research in the field of functional foods (Cox, Koster, & Russell, 2004) and technology-based selfservice (Dabholkar & Bagozzi, 2002). An interesting study in the field of GMF found that perceived behavioural control had a negative influence on the intention to eat a GM tomato, and the attitude of relevant others had a positive relation with this intention (Saba & Vassallo, 2002). A study in India showed that the subjective norm was particularly important to people's attitude towards new processed foods in this culture (Choo, Chung, & Pysarchik, 2004).

Perceived behavioural control and social norm have not received much attention in the literature on consumer acceptance of food technology and innovations. Outside the food domain, in the area of web personalisation, perceived trialability was found to have a positive effect on acceptance (Greer & Murtaza, 2003). Social pressure – the extent to which a person believes he should use the innovation for obtaining a higher social status – was found to mediate the relationship between age and the use of cellular telephones (Kwon & Chidambaram, 2000), with older consumers experiencing more social pressure to use cell-phones. It can be expected that pressure from the social environment will exert its influence in other cases as well. Outside of the food domain, adoption of an innovation in peer groups had a positive relationship with perceived usefulness. The higher the social presence of e-mail, the more users would find it appropriate for a wide range of communication tasks. Furthermore, the degree of social influence exerted by supervisors (i.e. the use of the innovation by the boss) appeared to predict perceptions of usefulness of an e-mail system, and thereby system use (Karahanna & Straub, 1999). We believe that the degree of social influence is also relevant in the food context, as eating is, by its very nature, a social activity.

In sum, perceived behavioural control and subjective norm have received only limited attention in studies on consumer acceptance of food technology and innovations. Research on food acceptance in general and innovation acceptance research in non-food domains, confirms that this may be an important proximal determinant but this has yet to be verified through extensive empirical research on consumer acceptance of food innovations.

Previous empirical research into distal determinants

Distal determinants of consumer adoption of innovations are easy to measure, but tend to have a low explanatory power as their effects are mediated through more abstract consumer perceptions. Our framework distinguishes between features of the innovation to be adopted (e.g., price), of the subjects potentially adopting it (e.g., age), and of the social system in which the innovation is introduced (e.g., collectivistic, as opposed to individualistic, culture).

Innovation features

Ten papers found innovation features to have an influence on measures of acceptance, mostly behavioural intention. At the lowest level of abstraction are determinants like price (Cestre & Darmon, 1998; Deliza, Rosenthal, Hedderley, MacFie, & Frewer, 1999; Deliza et al., 2003), complexity (Cestre & Darmon, 1998), convenience-related features, taste properties (Deliza et al., 2003), and physical appearance (Rimal et al., 2004), all identified in the area of food. In the context of foods that help prevent disease, Childs and Poryzees (1998) found that both delivery method (natural foods), and naming of the product (user-friendly name), had a positive influence on consumer belief in the diseasepreventing properties of foods, and thereby on purchase interest. Likewise, the food-processing technology with which cheese is produced was also found to influence purchase likelihood. Genetic modification was deemed the least acceptable method of production compared to traditional methods, which were most acceptable to the majority of respondents (Frewer, Howard, Hedderley, & Shepherd, 1997). Loureiro and Bugbee (2005) similarly found that type of modification affected consumers' willingness to pay for GM tomatoes. For example, when modification resulted in enhanced flavour, enhanced nutritional value or in pesticide reduction, consumers were willing to pay more for the modified product, which confirms our distinction between proximal and distal determinants.

Innovation features, the objectively measurable characteristics of the innovation, are not always easily separable from consumer perceptions in terms of their definition and their application in empirical studies. Previous research confirms the framework's contention that their effect on consumer acceptance is mediated through more proximal perceptions, mainly of cost/benefit and risk and uncertainty.

Consumer characteristics

Socio-demographic variables, whilst easy to measure, represent consumer characteristics with generally low explanatory power. More specifically, socio-economic status, income, nationality, age, gender, race, and familiarity have been found to have significant effects on one or more measures of innovation acceptance (Bogue, Coleman, & Sorenson, 2005; Bouyer et al., 2001; Cardello, 2003; Choo et al., 2004; Costa, Deliza, Rosenthal, Hedderley, & Frewer, 2000; Finucane et al., 2000; Florkowski, Elnagheeb, & Huang, 1998; Loureiro & Bugbee, 2005; Magnusson & Koivisto-Hursti, 2002; Palmer, 2003; Rimal et al., 2004; Siegrist, 1998, 2000). The phenomenon that white males perceive the risks of health and technology hazards as low compared to white females and people of colour is referred to as the 'white male effect' (Slovic, 1999). This effect is thought to be explained by socio-political factors including worldviews (e.g., individualistic, egalitarian) (Bouyer et al., 2001; Palmer, 2003).

Knowledge and expertise were consistently found to be determinants of risk perceptions, attitude towards gene technology and GMF and of dietary behaviour, but the direction of the association varied. Expertise increased consumers' risk perception of a broad range of hazards (Bouyer et al., 2001), whereas knowledge about gene technology and GMF had a positive effect on attitude (Siegrist, 1998; Verdurme & Viaene, 2001). Knowledge about food safety appears to reinforce consumer intention to purchase irradiated beef (Rimal et al., 2004). Science knowledge had a negative relationship with risk perception about biotechnology (Savadori et al., 2004). Research outside the food domain confirms the complex relationship between knowledge, expertise and adoption. Existing relevant knowledge was shown to increase consumer preferences for continuous (i.e. incremental) innovations. For discontinuous (i.e. disruptive, radical) innovations, however, this was only true when this consumer expertise was accompanied by supplementary knowledge, enabling the knowledgeable consumer to understand and appreciate the discontinuous innovation (Moreau, Lehmann, & Markman, 2001).

In terms of more enduring psychological determinants, world views such as universalism and hedonism had an impact (negative and positive, respectively) on attitude and intention to buy GMF (Honkanen & Verplanken, 2004). An interesting and very relevant set of traits are innovativeness-related characteristics. Reverting to Rogers' work, his classification of consumers into segments of adopters was also based on consumers' innovativeness. Food specific personality traits such as food neophobia and the opposite willingness to try new foods was studied and found to exert an effect (negative and positive, respectively) on new food behaviour in various papers (Tuorila, Lähteenmäki, Pohjalainen, & Lotti, 2001; Urala & Lähteenmäki, 2004; Verdurme & Viaene, 2001).

General attitudes, partly based on previous experiences, may also affect consumer acceptance of food innovations in a top-down manner. These general, relatively stable attitudes can be categorised into several main topics: science and technology (Cardello, 2003;

Grunert et al., 2003; Stolt et al., 2002; Verdurme & Viaene, 2001), environment and nature (Grunert et al., 2003; Siegrist, 1998; Verdurme & Viaene, 2001), health and nutrition (Bogue et al., 2005; Frewer et al., 1998; Grunert et al., 2003; Lähteenmäki et al., 2002; Saba & Vassallo, 2002; Verdurme & Viaene, 2001), sense of ethics (Tanaka, 2004a), and altruism (Stolt et al., 2002).

Previous research, which has focused on consumer characteristics, has centred around four groups: sociodemographics, knowledge, personality and general attitudes or values. This empirical evidence provides good support for the inclusion of this concept in our conceptual framework.

Social system characteristics

Characteristics of the social system, which can potentially determine acceptance of innovations, have not received widespread attention in the research literature. However, it is important to realise that developments in the market place are always dependent on their social context. The acceptance of a food innovation is not only related to the innovation itself but also to the nature of the economic, political and social environment in which food choice takes place (Henson, 1995). For acceptance of new technology it is important that technology fits with and is embedded in the daily public discourse (te Molder & Gutteling, 2003). A qualitative study into the discourse of GMF revealed that an important barrier is that scientists tend to engage with the public from their own frame of reference thereby causing an inability to connect with the other members of society (G. Cook, Pieri, & Robbins, 2004).

Social trust – the willingness to rely on those responsible for decision-making related to technology management – is shown to be a key predictor of perceived benefits and risks of several technologies. Social trust is in turn determined by shared values (i.e. people holding similar salient values), another element of the social system (Siegrist, Cvetkovich, & Roth, 2000).

Religion is important for almost every culture and still plays a role in influencing consumer behaviour. Fam, Waller, and Erdogan (2004) investigated a range of controversial products and found that religion is indeed an indicator for the offensiveness of these products. For example, Muslims found the advertising of gender/sex-related products, societal related products, and health and care products most offensive compared to Christians, Buddhists and non-religious believers. This might have implications for marketing innovations as well; imagine a technology appealing to feelings of ‘hampering with nature’ or ‘playing God’, as is the case with GM.

In sum, social system characteristics as a macro determinant have received only limited attention in previous research, but several studies confirm their importance as a determinant of consumer acceptance of food innovations.

Previous empirical research into communication

Communication is important in determining how innovative science-based products and services are received by the consumer, as it links the concrete, distal determinants and the proximal, psychological constructs in our framework. Communication extends beyond the sheer exchange of facts. Persuasive communication is related to matters of judgment, rather than to certainty. This is particularly important for communication surrounding controversial issues, such as technological innovations (Frewer et al., 1999; Simons, 2001).

Various aspects of communication play a role. In the context of GMF, the importance of characteristics of the source that brings the message was shown; a trusted source had an indirect positive influence on attitude (Frewer et al., 1999). In the context of the health hazard of lead in drinking water, it was demonstrated that interpersonal communication (by health professionals) was more effective when attempting to get people to adopt preventive behaviours compared to mass media and impersonal pamphlets distributed among the residents potentially at risk (Griffin & Dunwoody, 2000).

The type and amount of information is repeatedly found to play a significant role in acceptance of innovations. Deliza et al. (2003) showed that information on the label of foods produced with non-conventional food-processing technology promoted a more positive attitude towards the product through perceptions of benefits. Safety and handling information on the package of irradiated beef reinforced purchase intentions and even actual purchase (Rimal et al., 2004). In another study, willingness to pay for irradiated food increased when information was positive, but lowered when information was negative or if the information was both positive and negative (Fox, Hayes, & Shogren, 2002). The amount of information influenced the intention to adopt high-technology products through consumer perceptions of performance uncertainty, as shown by Ziamou and Ratneshwar (2002). They found that more information about the new product reduced consumers' uncertainty about its performance when the product had a familiar functionality (i.e. what a product does for the consumer), but increased performance uncertainty when the product had a new functionality. Visual exposure to products and statements about safety and benefits of the use of several food-processing technologies raised consumers' expected product liking in research by Cardello (2003). A large-scale cross-national experimental study showed that various types of information provision did not result in attitude change towards GMF. In fact, information material even activated the, often negative, pre-experimental attitudes, decreasing the probability of consumers' choosing the GM products (Scholderer & Frewer, 2003).

Media discussion of risks of GMFs had a differential impact on public perceptions of benefit and risk in a study by Frewer et al. (2002). When media attention was focused on GM foods in the media, risk perceptions increased temporarily, while benefit perceptions diminished more permanently. Another communication issue, related to concern and trust, is communicating risk uncertainty. Admission of risk uncertainty was found to improve consumer attitudes towards GMF by Frewer et al. (1998). It is notable that experts appear to believe that that information provision of risk uncertainty would increase public distrust in science (Frewer, Hunt et al., 2003).

An aspect of communication closer to the receiver is confidence in information, which was crucial for consumers' willingness to use functional foods (Urala & Lähteenmäki, 2004). Another example is interest in information related to food production, which increased when people were more fearful of GMF (Laros & Steenkamp, 2004).

Communication affects how distal characteristics are perceived by consumers, and it is these perceptions which will eventually determine consumer intention to adopt an innovation. The communication source appears to be important, as is the type and amount of information, the interest and confidence consumers themselves have in this information, and the way innovations are discussed in public. Communication and information are particularly important in situations where people have to rely on judgement rather than certainty, which is certainly the case for innovations.

This section has described and categorised a body of empirical support for our theoretical framework. For all the constructs we defined, a certain amount of evidence is available in which the constructs are related to a measure of innovation acceptance. The group of perceived benefits has received the largest research attention so far, compared to the other constructs, whereas perceived behavioural control and subjective norm have been studied less intensively in the food area. Also, interactions between determinants have been studied to a limited extent and require future attention.

Discussion

We substantiated our framework by mapping existing studies onto it, to provide it the scientific body it requires. This analysis confirms that the framework is comprehensive in capturing all of these studies. Our mapping of existing studies (see Table 3.1) shows that none have captured all the determinants of consumer technology acceptance comprehensively. Most studies focus on a subset of determinants, with a dominant focus on consumer characteristics, perceived cost-benefit considerations, perceived risk and uncertainty, and the effect of specific features of the innovation, which is in line with arguments put forward by Cardello (2003). The effect of communication on consumer acceptance has also attracted considerable research attention. However, research into social system characteristics, subjective norm and perceived behavioural control has received much less research attention. In terms of future research, the latter three determinants would require more attention. In terms of proposed relationships in the framework, we found empirical examples for almost all of them. The only two relations that have not previously been addressed are the influence of innovation characteristics on the subjective norm and of social system characteristics on perceived behavioural control. Intuitively, this may make sense, but it may also provide opportunities for future research to investigate these relations. A further striking result from our review is that most studies focused on specific benefits delivered by the innovation and relatively few on the specific cost-benefit trade-off that occurs between the perceived advantages and disadvantages of using the new technological innovations.

We are aware of the fact that a literature review is never completed, as scientific research continues to progress. However, up to date no studies exist that test the full complexity of the framework. The framework we propose is well based in the existing scientific literature, but is still a 'mind model'. What is needed to further substantiate and possible refine the framework is a comprehensive empirical test of it to also assess the relative importance of the determinants in shaping consumer acceptance of new food technologies and food innovations.

Our conceptual framework is largely built on retrospective studies of consumer acceptance of innovations. But as a 'mental model' it is also suitable for use as a structuring and decision tool in anticipation of consumer acceptance of current or future innovations. Such foresight into likely consumer response is particularly important for major innovations that have potentially large societal benefits but at the same time may also generate consumer concern. From genetic modification of crops and foods we have learned that the public has become increasingly wary of innovations if these incorporate possible risks, especially if previous and thorough debate about implications did not take place (Sjöberg, 2004). Considering these sensitivities in advance and acting on it, may prevent misinterpretation and ultimately rejection of the technology and its innovations.

The case of nutrigenomics

In this section we will use the newly developed framework to reflect on the possible determinants of consumer acceptance of nutrigenomics. As argued before, nutrigenomics is a particularly appropriate case as it potentially involves highly relevant consumer benefits (health maintenance and improvement) but may also generate considerable consumer concern due to its genetics associations.

In terms of *cost-benefit perceptions*, the benefits of nutrigenomics are potentially high; a gain in personal health could be achieved with just nutrition as the tool (van Trijp & Ronteltap, 2007). Health benefits relate to the maintenance of health (adding health to years), improving performance (e.g., in sports) and ultimately longevity (adding years to life). At a societal level, nutrigenomics may contribute to healthier food consumption and reduction in health-care costs. This brings in the issue of which group in society will benefit the most of nutrigenomics. Drawing the parallel with genetic modification, industry was the only obvious group with benefits from genetic modification of crop seeds. There were no better, healthier or cheaper products available for consumers, whereas they felt they were confronted with the possible risks accompanying GM. Another benefit nutrigenomics can deliver is attributable to the simplification of dietary choice (van Trijp & Ronteltap, 2007). Nutritional information based on genomics is specifically aimed at a particular individual or information receiver, which makes it highly relevant, and a useful tool in making food choices. A cost factor of personalised nutrition is the price premium that will have to be paid for this personalisation (van Trijp & Ronteltap, 2007). Nutrigenomics tests currently on the market in the US cost between $400 and $500 for broad-based analysis and fairly general advice (Oliver, 2005).

A prominent aspect of nutrigenomics is related to *risk and uncertainty*. Divulging personal information to third parties, a necessary condition for constituting personalised advice (Karat et al., 2003), may introduce concerns about privacy. Genetic information is stable over time, potentially interesting for various parties and it is still uncertain what exactly will be its future use. Consumers may be uncertain where information about their DNA will be stored and whether it may be used against them (Chadwick, 2004). As a result, risks of loss of privacy, loss of employment or insurance will be likely consumer concerns (Oliver, 2005). They may also experience personalisation as an undesirable interference with personal preferences, and as an attempt by marketers to persuade them (Simonson, 2005). Besides consumer perceptions, considerable scientific uncertainty is involved in the development of nutrigenomics as it is a young science. The predictive validity of genotype information for phenotypic conditions is crucial, as is the extent to which the effect of genes can be attenuated by nutrition. Both seem to be limited at this point in time, especially for complex diseases such as diabetes and obesity (Kutz, 2006; van Trijp & Ronteltap, 2007).

Perceived behavioural control in the context of nutrigenomics can be expressed in terms of the way people can, and will, respond once their genetic profile has been assessed. Imagine that the test results show that an individual has a certain genetic disorder. Will he change his lifestyle in order to prevent this disorder? Or will he become deterministic and change nothing at all, as his genes have already condemned him to the disease? Perceived self-efficacy, or consumers' confidence in their own ability to act upon the test results (Ajzen, 1991), will be a determinant of their behaviour. Much is related to the issue of empowerment of the individual consumer in terms of access to information and improved decision making (Bouwman et al., 2005). Clarity about which actions an individual can take after the genetic test is necessary to answer these questions.

As to *subjective norm*, the family doctor can play an important role in the societal introduction of nutrigenomics. Traditionally, family doctors are among the most important and trustworthy sources of nutritional information (van Dillen, Hiddink, Koelen, de Graaf, & van Woerkum, 2004), so they – or other authoritative medical sources – can be an important gatekeeper in the process of advising consumers about nutrigenomics tests and personalised nutrition. Furthermore, the opinions and behaviours of peers, for example friends or colleagues, are also likely to have a strong impact on consumer adoption of nutrigenomics. In sum, there is a strong need to develop the social networks that support the uptake of this new technology.

When considering the distal determinants of consumer acceptance of nutrigenomics and personalised nutrition, many likely relations with the proximal determinants appear. One highly important *innovation characteristic* is the extent to which following personalised dietary guidelines is effective. This has a direct effect on the perceptions of benefits delivered and behavioural control. Note that there are two types of nutrigenomics applications: diagnostic genomics tests and nutritional products stemming from them (Oliver, 2005), both with different consequences for consumer acceptance. Another aspect is the terminology used for the technology and the innovation. Burgess' (2003) research has shown that 'genomics' is susceptible for associations with genetic modification, and a recent American survey revealed that the term 'personalised nutrition' was markedly preferred by consumers over 'nutrigenomics' or 'nutritional genomics' in both appeal and relevance (Oliver, 2005). Furthermore, it is important to realise that nutrigenomics in itself is a complex science. It requires considerable knowledge about health, nutrition, nutrients, genes and physiology in general to understand how personalised nutrigenomics-based advice might work.

Consumer characteristics too are likely to influence proximal determinants of nutrigenomics acceptance. The genotype is the crucial consumer feature for personalised dietary advice, but as it is sensitive and stable information, it can trigger perceptions of risk and uncertainty. The people who are likely to be the innovators for using applications of nutrigenomics are those experienced with (diet-related) diseases, personally or in their close environment. They are motivated to take preventive actions and prone to be interested in nutrigenomics deliverables in an early stage of its development. Other potentially relevant consumer characteristics in the context of food innovation acceptance are habits. People do not always decide after in-depth, deliberate reasoning, especially in potentially risky food consumption situations (Fischer, Jong, Jonge, Frewer, & Nauta, 2005).

The difference in public reception of GMF between the US and most European countries demonstrates clearly what influence the *social system* can have on societal responses (Gaskell, Bauer, Durant, & Allum, 1999). Culturally embedded socio-ethical, moral and religious obligations can cause a reluctance to 'interfere with nature'. Another characteristic of the social system is the increasing financial burden of diet-related diseases such as diabetes, obesity, and certain types of cancer (Oliver, 2005), which strengthens the need for solutions. The earlier discussed role of health care practitioners as providers of nutrition information depends on their level of education and motivation. In general, physicians have been undereducated and under-interested in how diet can affect health (Oliver, 2005). More broadly, the health care establishment is slow to adopt new practices, and will not recommend their use until scientific evidence accumulates (Oliver, 2005). Legislation is another relevant factor at societal level. Under current regulatory frameworks, the rules of the European General Food Law Regulation are applicable to all foodstuffs. Furthermore, legislation on dietetic foods, food supplements or novel foods, and two proposals on nutrition and health claims and the addition of substances to foods, may be applicable to nutrigenomics products, depending on their nature and their use (Coppens, Fernandes da Silva, & Pettman, 2006). Currently, claims related to reducing risk of disease (or maybe even curing disease) – the type of claims most likely to be useful for nutrigenomics-based products – are prohibited (van Trijp & Ronteltap, 2007). Due to the amount of regulations and procedures to be followed, getting nutrigenomics products ready for the market will be an expensive and time-consuming process (Coppens et al., 2006). This may have large implications for the type of companies able and willing to invest in nutrigenomics products.

Communication surrounding nutrigenomics will play a crucial role in its development. Nutrigenomics is a complex science, and thus needs to be simplified by understandable messages that communicate the tangible benefits delivered (Oliver, 2005). If information is too complex for consumers, they tend to be more sensitive to superficial information than to in-depth and detailed scientific information (Petty & Cacioppo, 1986). This is exemplified by the influential statement on the part of Prince Charles in the discussion on biotechnology, when he referred to GMFs as "Frankenstein Foods"[4]. Despite the need for simple and clear messages, communication does not equal education, i.e. a one-way process from expert to layman. The so-called deficit model, still a popular paradigm among experts, states that it is a lack of knowledge among consumers that leads to scepticism with regard to technological innovation and science in general (Wynne, 1991). Our review shows that consumer knowledge is indeed a determinant of innovation acceptance, but that it is certainly not exclusive. A lack of communication, for example on scientific uncertainties, can in itself be a source of consumer scepticism (Frewer, 2003). Communication as an iterative two-way process is needed to pro-actively involve the public in the development of nutrigenomics.

Conclusion

Due to a lack of published empirical studies on consumer evaluation of nutrigenomics, this case could not be discussed exhaustively. However, the utility of the proposed framework demonstrates that it can be useful in the identification and structure of the many triggers and barriers that an emerging science such as nutrigenomics will face before it will acquire wide societal acceptance. The framework helps in identifying critical success and failure factors for the further development of nutrigenomics and the possible innovations emerging from it. To fully do justice to our framework, and the complexity of this new science area, future research

[4] http://news.bbc.co.uk/onthisday/hi/dates/stories/february/5/newsid_4647000/4647390.stm (Accessed October 9, 2006).

should involve a wide diversity of stakeholders, such as scientists, business people, policymakers, health-care professionals and consumer interest groups, to jointly assess the many factors involved in consumer acceptance and to design the appropriate strategies and actions to manage consumer expectations.

4

EXPERT VIEWS ON NUTRIGENOMICS

Critical success and failure factors

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Introduction

Science and technology have a reciprocal relationship with society (Rivers, 2002). Much of modern society's progress is attributable to science and, in turn, technological development critically depends on societal acceptance. Meeting customer needs is considered an important driver of new product success (Henard & Szymanski, 2001). The rapid market penetration of mobile telecommunication (Gruber & Verboven, 2001), for example, illustrates how fast a technology can reach large-scale adoption by the public if it satisfies the right conditions. The mobile phone served consumer wants and needs, e.g. accessibility and flexibility, which is identified as a precondition for consumer acceptance of new media products and services (Picard, 2005). In contrast, there are numerous examples of technologies that encountered public resistance and therefore did not reach full market potential, for instance nuclear energy (Wiegman, Gutteling, & Cadet, 1995) and genetic modification of foods (Gaskell et al., 2000). Low perceived benefits and high perceived risks, important determinants of attitude towards new technology (Frewer et al., 1998), are likely to have contributed to public opposition in these cases. The least that can be concluded is that these technologies did not approach society's needs and concerns appropriately.

As to acceptance of new technologies, innovations are never accepted completely and immediately by the public; they usually take a number of years to diffuse (Rogers, 1995). In his seminal theory of diffusion of innovations, Rogers (2003) confirmed the finding of earlier research that most innovations have an S-shaped rate of adoption. The variation lies in the slope of their curve. Some innovations diffuse rapidly creating a steep S-curve; other innovations have a slower rate of adoption showing a more gradual slope of the S-curve.

Consumers need time to accept innovative scientific progress, though there remain cases where acceptance does not occur at all. In order to understand how societal acceptance of new technologies will develop over time, a certain degree of foresight is needed. Given the dynamics of public acceptance, which show that the majority of consumers accept an innovation quite some time after its introduction, the average consumer is most likely not the best source of information about future societal acceptance of new technologies. This observation is acknowledged in two different research approaches: von Hippel's (1986) Lead User Method and Rogers' (2003) classification of adopters. The rationale behind these methods is that there are specific groups of users that are ahead of, and influence, the bulk of the market in terms of need articulation and adoption of innovations.

The Lead User approach is based on the premises that lead users have a high incentive to solve a particular problem and that they are ahead in time of the other members of the target market. For example, the lead users for a company developing running gear would be top-class sportsmen, who are highly motivated to have access to the latest and best equipment possible before the hobby-runners do. Lead users may even develop the innovation themselves as a solution to a problem they encountered. Rogers used a classification system of adopters on the basis of innovativeness. In this classification an early group is identified, consisting of a very small percentage of the population, called *innovators*. The innovator plays an important role in the diffusion process by importing the innovation from outside of the community's boundaries, and is therefore also an early source of information for those who seek to understand issues that will become relevant for the majority of adopters later on. Both approaches have in common that they are based on a specific group of actual users, who can be a good source of market information.

For radically new, technology-driven products and services the situation is more complicated as the adoption curve is supposedly flat and elongated and the impact potentially huge. Under such circumstances, where there is no real-world experience with the innovation another informed group in society might serve as the best source of information. Some people have a particular influence on the beliefs and actions of other individuals. They are often denoted as *opinion leaders*. Expert opinion leaders exert influence through their authority and status (Greenhalgh, Robert, MacFarlane, Bate, & Kyriakidou, 2004). To identify the critical factors for the future development of a controversial new technology, expert opinion leaders like scientists, policy makers or consumer representatives are likely to be a useful group. However, to generate a complete view a variety of different experts are needed as each individual or group has a specific angle from which the topic is evaluated. A synthesis of the views of a range of experts can facilitate insight into future critical factors for the successful introduction of new science in society (Ronteltap, van Trijp, Renes et al., 2007).

As a specific case of new technology in the domain of food and health, we focus on *nutrigenomics* in this paper. Nutrigenomics as a scientific discipline has been defined as focusing on 'understanding how nutrition influences metabolism and maintenance of the internal equilibrium in the body, how this regulation is disturbed in the early phase of a diet-related disease and to what extent the individual genotype contributes to such diseases' (Müller & Kersten, 2003). Some authors (e.g. German et al., 2004) have argued that the applications of nutrigenomics in the form of personalised foods hold the potential to shift the food market from a technology push into a consumer pull system, where the consumer's preference for optimal health is a major driver for food choice, and as a consequence for food production. Hence in the empirical research we include both the science of nutrigenomics and its possible application in the consumer market and use as a definition for nutrigenomics: 'Understanding the interaction between nutrition and the human genome – in view of disease prevention and recuperation and health optimisation – to use that knowledge to develop tailored nutrition of food products'. The promise of nutrigenomics is widely recognised (Astley & Elliot, 2005; Fogg-Johnson & Merolli, 2000; Hirsch & Evans, 2005; Müller & Kersten, 2003), but its development and applications are still highly unclear and potentially controversial. The aim of this study is to use expert opinion leaders in the field of nutrigenomics as source of knowledge and experience for the identification of critical success and failure factors for the development of this new area.

Background

There are several issues surrounding nutrigenomics that are unclear and uncertain at this point in time. First, the field itself is not well demarcated yet. Some argue that nutrigenomics is exclusively the scientific study of the effects of nutrients in molecular-level processes in the body and the effects dietary components have on increasingly small groups of individuals with similar genotypes (Fogg-Johnson & Merolli, 2000), while others include the development of applications with the goal of promoting human health as well (Cain & Schmid, 2003).

Second, it is still highly unclear how nutrigenomics will develop from fundamental research to consumer applications. This includes not only the time aspect, but also what nutrigenomics spin-offs will be at the marketing stage. Whether only dietary advice will be a realistic application or if there will also be personalised or indeed individualised food products, or none. And how far will scientific knowledge have to be developed before applications appear on the market? Although nutrigenomics is in its infancy, various companies are selling DNA-based tests at the moment. Direct-to-consumer marketing of health-related genetic tests has recently appeared in various media; at least 14 websites offer genetic tests without intervention by a physician of which some are based on tests without proven validity (Holtzman, 2006). Although the majority of these marketing activities were US-based, it gives an indication of what is already being marketed without extensive scientific underpinning. Especially in the case of nutrigenetics tests the added value of the DNA-based advice over standard dietary advice is limited. So far, only very few unambiguous relations between genotype and health – manipulable through food consumption – have been identified. In order to have more insight into the potential of nutrigenomics to facilitate an open debate, it is important to establish the time frame and validity of its applications.

Third, it is to be seen which critical success and failure factors will determine consumer acceptance of nutrigenomics. This technology could have a large impact on individual quality of life and society as a whole, such as a leap forward in public health and privacy concerns about management of sensitive genetic information. If the large-scale introduction of potential spin-offs is to happen, it is still several years ahead. The potentially high societal impact of nutrigenomics, combined with the uncertainty about its applications and its timescale, makes it crucial to start the identification of the determinants of its acceptance now. By doing so, societal needs and concerns can be incorporated in setting the preconditions of nutrigenomics, which in turn facilitates public acceptance, or at least reasoned rejection.

Only a few expert opinion leaders in the field of nutrigenomics are working on its development at the moment. Current development mostly takes place in laboratories by, for example, molecular biologists. This introduces an important group of experts for nutrigenomics development, i.e. academics. Within this group, several other scientific disciplines are relevant as well for the technology's development. Food scientists, for example, who have most insight into the possibilities and limitations in personalising food products, or bio-ethicists, who have experience in evaluating previous developments in biosciences.

Besides scholars, other experts are to play a more active role in a later stage of development. Governmental bodies are responsible for guarding public health and have the duty to determine the legal frontiers of scientific innovations and their applications. Bearing in mind the preventive potential of (nutri)genomics, coercive strategies to undergo genetic screening might be under discussion (van den Daele, 2006). Health claims made by the food industry form another issue that needs to be addressed by legislators. Closely related is the earlier observation that DNA-tests currently on the market are not always scientifically sound and might oversell the technology.

Food and biotech companies are also a crucial expert group, as they will be developing large-scale consumer applications based on insights from genomics research. They need to be convinced that there is a potential market for the new products and services before they invest money and effort. Their insight into market success of earlier technological innovations may be of great help in anticipating the marketing potential of nutrigenomics. Non-governmental interest groups are often highly influential in shaping public opinion. In the context of genomics patient representatives are likely to be very interested in the preventive ability genomics has to offer. They might be the first group to adopt spin-offs from nutrigenomics research. More general consumer organisations may be concerned with the possible infringement of privacy. Located at the end of the 'nutrigenomics supply-chain' are health care practitioners; the health professionals who are confronted with questions from the public on the one hand and information from experts on the other. Basically, they could be in a position to bring nutrigenomics to practice by providing advice, controlling compliance, and monitoring effects on health. The media function as the link between all other groups, adding their own interpretation depending on their type and goal. For involvement and support it is important to shape the boundaries of the technology and its applications in cooperation with all those involved.

In summary, we have argued that several aspects of nutrigenomics are uncertain at the moment, hampering a clear view on its potential future. In particular the definition of the term itself, its development over time and factors controlling success and failure need to be clarified. In this paper, we attempt to create a grounded image of the future of nutrigenomics on the basis of relevant expert knowledge. For that purpose, we interviewed experts from various disciplines discussed above, i.e. science, government, industry, non-governmental organisations, health care and media.

Method

Individual semi-structured interviews

The methodology we used was the semi-structured interview. Semi-structured interviews combine a structured agenda with the flexibility to ask additional questions. Goals are to obtain general information relevant to specific issues, and to gain insight into these specific issues. Interviews are audio-recorded and later transcribed providing a protocol for detailed analysis. Semi-structured interviews are composed of a number of pre-determined open-ended questions in the form of an interview schedule, intended as a guide to the researcher. In an expert interview, the interviewee is included in the study in the capacity as an expert in a certain field and as representative of a specific group of experts.

Our semi-structured interview consisted of three main parts. In each part, an open question was asked first to allow participants to express their view in their own words. To accomplish more comparable results, the next step was to present interviewees with specific stimulus material to respond. The first part served to define nutrigenomics and was represented by one completely open-ended question *"Can you give your definition of the term 'nutrigenomics'?"* and a request for a reaction to our pre-defined interpretation of nutrigenomics as *"Understanding the interaction between nutrition and the human genome – in view of disease prevention and recuperation and health optimisation – to use that knowledge to develop tailored nutrition or food products."* Part two was included to determine how respondents envisioned the development of nutrigenomics in practice. It covered the topics of time span *"I would like to know how much time you think the development of nutrigenomics will take"* and examples of applications *"Can you give examples of how you think nutrigenomics- based products and services look when they enter the market?"*. During the interview, these two questions were often answered simultaneously as many interviewees used examples of nutrigenomics applications as a basis for time predictions. The third and last parts dealt with the identification of critical success and failure factors for the development of nutrigenomics. Respondents could elaborate on the promoters and inhibitors for nutrigenomics in their view in both an open-ended question (*"I will shortly outline two very divergent scenarios for the development of nutrigenomics. Scenario 1: Nutrigenomics has been stopped, has disappeared, has been 'frozen'; is dead. Scenario 2: Nutrigenomics is used widely, is applied generally; is alive. Could you indicate for both scenarios which critical success and failure factors determine whether the scenario will become reality?"*) and a closed question (*"I have a number of cards with factors that can influence the development of nutrigenomics: technological feasibility, marketing feasibility, political feasibility,* *legislation and consumer acceptance. Could you arrange these factors vertically, such that the top card means 'stimulates development most', and the bottom card means 'inhibits development most'?"*).

Participants

To achieve a balanced and comprehensive overview, a variety of Dutch experts relevant to nutrigenomics were approached for this study. Using the network of the Dutch National Genomics Initiative (a governmentally funded research investment organisation), we selected three to seven prominent individuals in each of the key expert groups and invited them to participate in our study. The response rate was 97%, resulting in 29 experts who agreed to take part. Table 4.1 gives an overview of the groups and the specific fields the interviewees worked in.

Table 4.1. Expert groups

	Main group		Specific professional field
A	Government	1	Ministry of public health, welfare and sports
		2	Ministry of education, culture and science
		3	National genomics initiative
B	Scientific disciplines[5]	4	Nutrigenomics
		5	Human nutrition
		6	Plant science
		7	Innovation science
		8	Food technology
		9	Molecular biology
		10	Ethics
C	Industry	11	Multinational food production
		12	Specialised nutrition
		13	Health insurance
		14	Pharmaceuticals
		15	Strategic communication
		16	Applied research in strategy, technology and policy
D	Non-governmental organisations	17	Environment
		18	Future image of technology
		19	Consumers and biotechnology
		20	Nutrition centre
		21	Technology assessment
		22	Patients
		23	Agriculture
E	Health care providers	24	Dietetics
		25	Family doctor
		26	Allergology
F	Media	27	Opinion journalism
		28	General science journalism
		29	Biotechnology journalism

[5] Our definition of scientific disciplines includes both the natural and the human sciences

Procedure

The data were collected in 2004. After making an appointment one of two researchers visited participants, mostly in their professional environments. They were asked whether they agreed to being audio-taped during the interview, and after verbal consent the research commenced. On average it took 50 minutes to complete the interview. Interviewees received a small gift to express our gratitude for their participation. After transcription of the interviews, respondents were given the opportunity to read the text, and all participants gave permission for using their interviews in further analysis.

Data analysis

All recorded interviews were transcribed and subjected to analysis with Atlas.ti, a software package for qualitative analysis. After transcription, text fragments were assigned codes using a 'bottom-up' approach, i.e. without strong a priori assumptions. The purpose of codes is to classify an often large number of textual data units into a smaller number of homogeneous categories. While coding, the text was examined line by line in search of cues specifically related to the goal of that particular question. To illustrate the rationale behind this approach, if a respondent would say: *"I think it is important that nutrigenomics is communicated to the public by a reliable source"*, this part would be given the code 'COMMUNICATION SOURCE'. This could either be a code that had already been used in another interview, if the content of the quote was similar, or a new code, if it was an opinion nobody in the sample expressed before. Next, further data reduction was achieved by combining several codes into 'families' that are meant to represent related codes on a more abstract level. Continuing the previous example, the codes 'COMMUNICATION SOURCE', 'COMMUNICATION TONE OF VOICE', and 'AMOUNT OF INFORMATION' would combine to form the family 'COMMUNICATION ASPECTS'. If one respondent would repeat what he or she had said before, this would not be coded again. As a result, one code was not assigned to one interviewee more than once. This served the purpose of avoiding a disproportionate influence of an opinion one respondent would repeat frequently on the overall results. The use of software in analysing the qualitative information allows for more objective assessment and facilitates more complex examination of the data (Barry, 1998).

Results

Defining the field

Firstly, we asked participants if they could define the concept of nutrigenomics in their own words. Six of the respondents initially said they could not answer this question, but after further probing all respondents gave their interpretation of the concept. All respondents understood nutrigenomics to be related to nutrition and genomics, using terms like 'genes', 'genome', 'DNA', or 'hereditary' on the one hand, and 'food', 'nutrition', or 'nutrient' on the other. What they disagreed on was whether or not at this stage, applications of nutrigenomics science should be included in the definition. There was no commonly shared view about whether nutrigenomics is merely science or whether it is also defined by the products and services derived from it. Another source of disagreement was whether the focus of nutrigenomics was either on the human genome or on the genome of human foods. While 17 of the respondents believed that nutrigenomics is about understanding the functioning of the human genome alone, six others had the opinion that it studies the genome of our foods, be it animals or plants. Some interviewees went as far as arguing that nutrigenomics is just a new term for food biotechnology, for example, a journalist said:

"I also interpret it [nutrigenomics] as intervening in the genome of plants in order to improve the quality of food. (...) So far, this gene-food was aimed at commercial revenues for the grower and the new development in gene-food is that you really get more functional, better food."

The six remaining experts shared the opinion that nutrigenomics studies both the human and our food's genome. An employee of an NGO said:

"It is the science of the function of genes of plants and animals for food, and the function of genes and their environment in humans related to digestion of food."

Table 4.2 summarises the diversity of opinions.

Table 4.2. Two major elements in defining nutrigenomics

	Human genome	Food genome	Human + food genome	Total
Applications	5	3	3	11
No applications	12	3	3	18
Total	17	6	6	29

The majority of experts believed that nutrigenomics should be defined as a field of science that studies the human genome, without mentioning goals or applications. With respect to differences in view between the groups of experts, a striking observation was that five out of six respondents from industry defined nutrigenomics as the study of the human genome as opposed to a study of the food genome. The only group in which the majority thought nutrigenomics is about studying the food genome is the media (two out of three). The remaining distribution of answers over the expert groups was fairly even.

The second question in this part asked experts to respond to our pre-defined definition of nutrigenomics, namely: *Understanding the interaction between nutrition and the human genome – in view of disease prevention and recuperation and health optimisation – to use that knowledge to develop tailored nutrition or food products*. Responses to this definition were specific to the three basic elements: (1) interaction between nutrition and the human genome, (2) the context in which this research takes place (health and disease), and (3) the aim of developing applications (tailored products). Thirteen experts agreed with this definition, evenly spread over the various groups. Seven disagreed with the first element of the definition, most of whom thought that the genome of our foods should be incorporated into the definition as well. Other criticism to the first element dealt with the suggestion of a direct interaction between nutrition and the human genome:

"I think that there are several more steps between nutrition and the human genome. (.) The foods you ingest first end up in your digestive system. There it is transformed by means of reactions catalysed by enzymes."

(government)

Five participants experienced problems with the second element; they believed that nutrigenomics does not only serve the goal of health promotion, but also other goals such as improving hedonic qualities of food:

"It contains more. Of course, it [nutrigenomics] is also about the taste and attractiveness of foods."

(media)

Four others disagreed with the application element of our definition; they argued that applications should not be included in the definition at all. Not surprisingly, these four also did not include applications in their own definition.

An interesting observation was that several experts questioned the assumption that nutrigenomics should lead to personalised nutrition. They reasoned that insight into the human genome might also lead to general recommendations for public health, for example, one argued:

"You insinuate that you only want to look at personal diets, that you just want to look at the differences between genes in us, humans, (…) but you can also look at the genes that are the same in all of us."

(NGO)

This first section of the interview shows that there is no unified view agreed upon by the experts about the definition of nutrigenomics. The majority agrees that it is a field of science that studies the human genome only, and that the definition need not necessarily include health-related food applications. However, the number of experts who think differently is also substantial, which might have implications for a public debate. For an open, honest and constructive debate about the desirable direction for nutrigenomics to develop in, a prerequisite is that the discussion is about the same topic.

Development of nutrigenomics

We asked respondents to express their view on the time frame in which nutrigenomics will develop: *"How much time do you think the development of nutrigenomics will take?"*. The different predictions of time span are displayed in Figure 4.1.

Above the time-line the predictions related to scientific elements of nutrigenomics development are shown, and below the line their expectations for market introduction of nutrigenomics applications. Although most experts expressed their uncertainty about their prediction, 23 of them expected personalised dietary advice or food products to reach the market at some point in time, ranging from 2010 to beyond 2050 with an average estimation around 2020. Scientific progress was predicted on shorter notice. Examples of these science-related predictions include a massive acceleration in the identification of genes' functions, or improved methods to model human metabolism due to our knowledge of the genome.

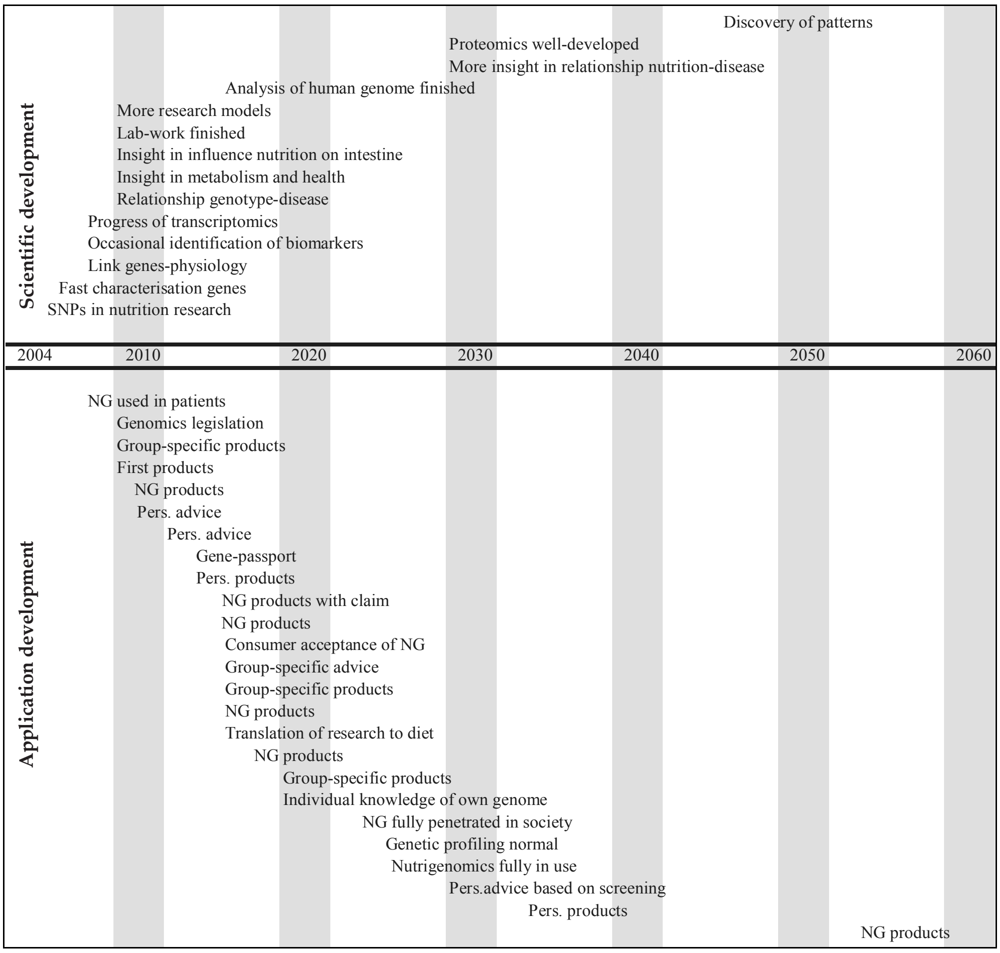

Figure 4.1. Experts' predictions for time span of nutrigenomics development (Pers.= personalised NG= nutrigenomics)

The other purpose of this part of the interview was to identify how experts envisioned nutrigenomics products and services at market entry. In total, 34 different potential applications were mentioned, of which functional foods[6] (17 times), products aimed at specific groups with similar genes (eight times), and personalised dietary advice (five times) were given most frequently. Flora/Becel ProActiv, the margarine that actively lowers blood cholesterol levels by means of added plant sterols[7], was mentioned as an already existing example of what nutrigenomics products might look like. The adjustment of existing food products was mentioned 10 times, for example, on the basis of people's intolerance for ingredients:

"I can imagine that some people have a certain sensitivity for certain nutrients (.), and that certain products will appear on the market that don't contain that nutrient."

(NGO)

There was a distinction in the degree of individualisation interviewees found realistic, similar to what was reported in the discussion of the definition of nutrigenomics. A scientist explained:

"Everything you get to know about individual sensitivity leads to recommendations for a healthy diet. But you will never want to restrict this to a subgroup, so you will end up giving this advice to everybody."

Dietary and lifestyle advices were another important group of applications, ranging from the recommendation of specific products to more holistic lifestyle advices.

Again, there is no unanimous view on nutrigenomics among our expert respondents. However, a general tendency is that they do not expect market introduction of nutrigenomics on short notice. Two believed that it will never reach that stage:

"So you really need to bring a product to the market that has a proven added value, and then you need to solve all these problems like scientifically sound, no side-effects and difficult business models. I don't think there will be products, I am very pessimistic, I don't think there will be genomics-based products."

(industry)

"No genes will be found that can be screened cost-effectively and on the basis of which you can give adjusted individual dietary advices."

(science)

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[6] Functional foods affect bodily functions beyond nutritional effects (Saher, Arvola, Lindeman, & Lähteenmäki, 2004).

[7] See www.proactivscience.com.

Critical success and failure factors

The third and last part of the interview aimed at the identification of factors important for the further development of nutrigenomics, so-called critical success and failure factors (CSFs). We outlined two opposite scenarios of the development of nutrigenomics, one stating that nutrigenomics will not subsist, and the other stating that nutrigenomics will be fully in use in society. The experts were asked to indicate which factors they thought would be crucial for each scenario to become reality. The factors they mentioned were grouped together into families (see Method) on the basis of conceptual similarity, and the families of codes were further categorised to form five main clusters of CSFs (see Table 4.3).

Table 4.3. Critical success and failure factors

Cluster	Family (# codes, # times mentioned)	Examples of codes
The group that benefits	Benefit for industry (5, 7)	Potential profit
	Benefit for consumer (25, 50)	Freedom of choice, ease of use
	Benefit for government (3, 3)	Cost-effectiveness of nutrigenomics in health care
Marketing and consumer	Marketing (15, 24)	Market segments relatively small
	Mentality consumer (17, 29)	Growing interest in nutrition and health
Communication and interaction with society	Communication aspects (13, 19)	Positive communication, reliable source
	Societal support (7, 12)	Occurrence of food scare related to nutrigenomics
	Education (2, 7)	Relative risk difficult term for consumer
	Public debate (6, 8)	Participation of all groups
Ethical and legal aspects	Ethical aspects (14, 23)	Medicalisation of food, privacy issues
	Legislation (12, 20)	Regulation of product claims
Scientific research	Technical/scientific aspects (19, 24)	Predictive value of genome for health limited
	(Scientific) resource allocation (4, 11)	Funding needed for expensive research

The five clusters are the following: (1) the group that benefits from nutrigenomics, (2) consumer attitudes and marketing feasibility, (3) how nutrigenomics is positioned and communicated in interaction with society, (4) ethical and legal constraints, and (5) hurdles in scientific research, which will be discussed below.

Most frequently, the delivery of benefits was discussed as a CSF for nutrigenomics with 33 codes categorised in this cluster. Different groups in society were identified as potentially reaping the benefits from nutrigenomics. Most importantly, benefits for the individual consumer or society as a whole were mentioned, although the focus varied. Thirteen participants spread evenly over the six expert groups named benefit for consumers in general. Consumer freedom of choice was brought up specifically by four different experts, for example:

"[The consumer will accept nutrigenomics,] just as long as there is freedom of choice. Look, people want to be able to choose between common nutrition of which they know it fits their genetic profile, (...) and genetically manipulated foods if they know that these are better for their health."

(health care)

Other types of consumer benefit were the ease of using nutrigenomics in daily life – an extension of people's quality of life – as opposed to the addition of years to life only – the improvement of hedonic qualities of food and the fulfilment of promises made by scientists. The last aspect also encompasses the fact that nutrigenomics has to be effective, that it should actually result in health improvement or disease reduction and furthermore, that these effects should be visible for the consumer.

Besides consumers, other actors in the field should also experience advantageous effects of nutrigenomics, more specifically industry and government. With respect to industry, making profit was not surprisingly mentioned as a crucial factor for the success of nutrigenomics by four experts from media, industry and NGOs. A scientist put forward the alarming increase in health care costs as a strong motive for the government to stimulate nutrigenomics.

CSFs related to marketing feasibility and consumer behaviour were represented by 32 codes. Important obstacles for market success of nutrigenomics were the size of target groups, as well as the question how to identify and reach these groups, for example:

"The groups of people with a link between a small number of genes and health for whom you can market clear products, will be very small."

(NGO)

"The people who invest heavily in their nutrition – not only money, but also effort and attention – are usually the people who least need a drastic change in their diet. (…) The point is that people who don't care (…) have little knowledge, a lower education, those are the people with obesity. Those are the people you actually want to reach with dietary advice."

(NGO)

A change in industry's course of business as a result of a shift towards personalisation is expected to be necessary:

"Our company sells through the retailer, so we don't often have 1-to-1 contact with the consumer. Maybe this means that we have to approach the consumer differently. We have to examine the feasibility through marketing."

(industry)

Another representative of industry was quite negative about the marketing potential of nutrigenomics:

"I don't foresee a business-model for nutrition (...). For nutrition you have two problems: to prove that it works and to prove that it is safe."

(industry)

Various aspects of consumer behaviour were considered to be important for the development of nutrigenomics. For example, respondents questioned the readiness of consumers to have knowledge of their own genes, as it might lead to a negative prospect that people may find too heavy a burden. On the other hand, as a scientist stated, the increased knowledge about the relationship between diseases and nutrition might function as a strong motivator for people to change their dietary pattern. Another potential failure factor was people's conservative attitude towards food, compared to other innovations. A scientist commented:

"Nutrition is something else than for example, the way personal computers entered our lives. Nutrition is something we have always had, and people ingest it daily. (…) It's not that consumers are so critical, but what they are used to is very decisive. I'm not saying they are not prepared to innovate, but that it is much more complicated than with cell phones and similar things."

Five experts made more positive remarks about consumer behaviour in relation to nutrigenomics, for example, the growing consumer interest in health, nutrition and, for example, sports. If being healthy and slim will (continue to) be a societal trend, this will stimulate people's interest in using nutrigenomics.

Communication, education, public debate, and promoting social support formed a fourth group of CSFs, totalling 28 codes over the entire data set. Participants mentioned various aspects of communication, of which tone of voice and source could be identified as common denominators. The tone of voice of communication was specified with various examples. The objectivity of information was one of those, considered to be a determinant for the level of public trust:

"Many people are being confused by contradictory views and they will choose the safe option. (...) What's important is that objective information is distributed."

(NGO)

The extent to which communication is motivating for the consumer was another aspect:

"You have to accompany things with good communication to the consumer, so that he will find it exciting to think about his health and how things work."

(science)

Information should also be in a consumer-friendly format, so that it fits consumers' notions:

"You need to bring the information to the consumer in a way that is truly consumer-friendly. So not schoolteacher-like: 'you have to eat a kilogram of broccoli today'."

(science)

Several interviewees argued that a positive framing of communication is more effective than a negative focus:

"Positive products are better than if people have to refrain from things. It's better to tell people: 'You should eat margarine A rather than margarine B' than to tell them: 'You can't have margarine at all'. In that way, they are not deprived of anything."

(government)

With respect to the communication source, two scientists said that it will be important that the source is considered reliable by the public. Ideally, government, industry and other actors should work together to accomplish this by, for example, establishing an acknowledged dietary advisor.

Educating the public was viewed a CSF as well, as many consumers will experience difficulties understanding the issue. An example of the complexity surrounding genomics was the concept of 'relative risk', which can be difficult to grasp for lay people. The opinion among the experts about establishing a public debate was not unambiguous. Some argued that having public debates is absolutely necessary; others were less convinced of its use. An argument against a public debate was for example, that only those citizens with the most extreme opinions are heard:

"With this kind of controversial technologies, you only always hear the most pronounced proponents and opponents, even if you select people arbitrarily. You don't hear people who are indifferent. In that way, you always achieve a distorted picture."

(government)

A last aspect of interaction with society was the creation of social support. A frequently mentioned inhibitor of public support was the occurrence of food scares connected with nutrigenomics. In addition, several ethical and legal consequences of nutrigenomics were brought up in the interviews, covered by 26 codes in total. Some were associated to the aspect of personalisation, for example, the impact on the family dinner, as members of one household might have to eat different meals. A related topic is the medicalisation of foods, i.e. the notion that nutrition will be viewed as fuel for the body only, ignoring the hedonic aspects:

"Should you harass people with all kinds of scientific information about such a fundamental activity that eating is, that may drastically change their enjoyment in life?"

(science)

Whether nutrigenomics will only be in reach of the elite was another ethical consideration. Two scientists and a representative of an NGO felt that nutrigenomics must be in the public domain, so available to all. Privacy issues, whether 'objective' or perceived by the consumer, were considered a bottleneck for the implementation of nutrigenomics. All of them originated in the management of sensitive genetic data and the possible misuse when leaked out.

Illustrating quotes:

"Well, an inhibiting factor will definitely be the ethical and privacy discussion. (...) The fear that data will be misused for life insurances, or mortgages."

(industry)

"The consumer won't want nutrigenomics, because this kind of information will only lead to misuse. If you know you have an increased risk of a certain disease, your insurer will want to know that. Or your employer. To whom does this information belong?"

(science)

Statements about legislation were mostly related to claims on products. The common view was that it should be clearly regulated what is and what is not allowed in terms of product claims in order to make nutrigenomics spin-off successful. Regulation of insurance was considered to be crucial by four respondents, and a final observation was about the role of European legislation, expected to develop soon and thereby influencing the development of nutrigenomics in the Netherlands as well. A journalist remarked:

"European legislation is quite critical with regard to modified foods. We are hardly rational in that respect, and maybe that has to do with the fact that we lack an FDA in Europe. (...) An attractive characteristic of the FDA in the United States is that it stands above politics. It is a scientific authority; if the FDA says something is safe, it influences governments, politics and the people. The Europeans, with the Dutch ahead, want a European food authority under the influence of politics. I am not too happy about that."

Besides CSFs related to implementation in and acceptance of society, 23 codes were associated with experts' concerns about scientific hurdles that still need to be taken. These concerns were related to either technical challenges or the allocation of research funding. The majority of this type of CSFs was about the complexity of the interaction between nutrition and health as an inhibitor of nutrigenomics development. Also the fact that most diseases have a multi-factorial and poly-genetic aetiology, meaning that it will be very difficult to identify and target responsible genes, was seen as an inhibitor. Eleven respondents thought that the costs of continuing the expensive genomics research would be a bottleneck for nutrigenomics. More specifically, government and industry both have to continue investing money in nutrigenomics research to secure its future in the view of these respondents.

In the second question of this third part of the interview we asked respondents to rank five pre-defined CSFs (technological feasibility, marketing feasibility, political feasibility, legislation and consumer acceptance) from 'inhibiting' to 'stimulating' for the development of nutrigenomics. Results of this ranking task are displayed in Table 4.4.

Table 4.4. Ranking of pre-defined critical success and failure factors

	# respondents ranking factor as most inhibiting for development	# respondents ranking factor as most stimulating for development
Technical feasibility	3	15
Marketing feasibility	0	12
Political feasibility	5	2
Legislation	6	3
Consumer acceptance	16	5

Sixteen experts expected consumer acceptance to be most inhibiting, while only three thought that technical feasibility would be most restrictive. Technical feasibility was considered to be most accelerating for the development of nutrigenomics by 15 of the respondents, and 12 assumed marketing factors to be most stimulating. This result largely reproduces the distribution of numbers of CSFs mentioned spontaneously to the first question of this part of the interview. The largest group of respondents expected factors related to public acceptance of nutrigenomics to be the most important challenge, while a minority believed scientific aspects to be the largest bottleneck. Slightly deviating finding from the second question is the considerable number of respondents who think marketing feasibility will be an important promoter of nutrigenomics development.

Even though the discussion of CSFs showed a diversified view on what will be important for the development of nutrigenomics, several main factors could be distilled. The group that benefits from nutrigenomics; consumer attitudes and marketing feasibility; how nutrigenomics is positioned and communicated in interaction with society; ethical and legal constraints; and hurdles in scientific research can be seen as commonly shared critical factors in descending order of importance.

Discussion

In this paper, we built a view on the future of a specific case of scientific innovation in the area of food and health. We extracted this view from experts' opinions, which together represent the field of nutrigenomics as a whole seen from different disciplines. We showed that there is no unanimity among experts concerning the definition of nutrigenomics, its development over time, and the critical factors that determine its success or failure. As to the definition of the concept, main differences in opinion were related to the type of genes under study (humans vs foods) and whether spin-off is part of the definition or not. Predictions of development differed with respect to the amount of time it will take nutrigenomics to develop and the examples of applications experts found realistic. The range of critical success and failure factors identified by respondents was wide, but a limited number of main issues could be distilled from the data.

Supported by the largest number of quotes, the question which group in society will benefit most from nutrigenomics can be considered the most important determinant of success for nutrigenomics according to our expert panel. Particularly whether nutrigenomics will deliver actual benefits to the individual consumer or society at large was stressed frequently as a major success factor. This finding is in concordance with a substantial body of literature. Innovation diffusion theory identifies the innovation characteristic of delivering relative advantage over preceding options to the user as an important predictor of success (Rogers, 2003). Empirical research in multiple contexts, such as gene technology (Siegrist, 2000), genetically modified foods (Frewer et al., 2002), and nuclear power (Tanaka, 2004b), also demonstrates the important role of (perceived) benefits for consumer acceptance.

Issues of marketing feasibility and consumer attitudes formed the second largest group of expected CSFs. Applying nutrigenomics implies that food industry would have to focus on increasingly small consumer segments on the basis of homogeneity in genes and related nutritional needs (Jiang, 2000). The customisation of products to these small segments of consumers requires substantial adjustments to current food supply chains which are based on large-scale production. One option to tackle this challenge would be to develop specialised foods for particular groups of people with similar genotypes, the feasibility of which depends on their willingness to pay a price premium to compensate for the extra costs involved in production, distribution and marketing. Another option would be to add specific ingredients to products at the very last step in the production chain, resembling a vending machine, to make the product fit the consumers' nutritional needs in-store (van Trijp & Ronteltap, 2007).

Communication about nutrigenomics and interaction with society will play an important role in the development of nutrigenomics. Public attitudes about new technologies have been mentioned in literature as one of the most important factors determining the likelihood of the successful development and implementation of technology (Frewer, 2003). It is crucial, therefore, that a certain level of social support for technological innovations exists. Experts specified various aspects of communication, such as the source, tone of voice and amount of information. Similar aspects were found in earlier research as well, for example, in the area of genetically modified foods (Frewer et al., 1999) and functional foods (Urala & Lähteenmäki, 2004). Respondents also identified other ways of interaction with society as CSFs, for example, the creation of a public debate.

By its very nature, nutrigenomics gives rise to a number of ethical and legal issues. Experts recognise this as a critical factor for its development. First, the association with genetic modification is easily made, as demonstrated by a Canadian study investigating consumers' hopes and concerns related to genomics research. When the topic of food was discussed, the issues raised were all examples of genetic modification of crops and foods, e.g. Golden Rice (Burgess, 2003). The medicalisation of nutrition, as well as the equitable accessibility for all to the benefits of genome-related research (the so-called Genomics Divide) and of course protection of sensitive data are all ethical matters that need to be addressed.

The scientific discipline of genomics has mobilised many researchers worldwide, and the advances made in the last decade have exceeded expectations. The early completion of the Human Genome Project, in which the human genome was sequenced entirely, is a good example of how fast genomics science has developed. The complexity of the genome itself, however, and the even more complicated interaction between the genome and health exemplify the hurdles that still need to be taken. These challenges were also identified by a number of experts in our study as important inhibitors of nutrigenomics development. Besides scientific uncertainties, other critical success and failure factors exist. Experts indicate that scientific and technical feasibility is the most important factor stimulating further development of the field, whereas consumer acceptance is the most important factor potentially inhibiting such further development. It thus seems that solving the scientific uncertainties is a necessary but insufficient condition for the nutrigenomics applications to blossom.

Several suggestions for future research as a result of our study can be made. First, we used a variety of experts in the Netherlands to cover the entire field of nutrigenomics in this country. As nutrigenomics is an emerging science internationally, it might be the case that experts in other countries view the development of nutrigenomics otherwise due to cultural differences or a different state of scientific affairs. Furthermore, legislation is different between countries (as for example in the case of stem cell research) and our study identified the accomplishment of international legislation as a factor that might influence national development of nutrigenomics as well. A cross-national comparison of expert samples to examine where similarities and dissimilarities exist would provide more insight into this influence of nationality.

Second, our research was carried out at one point in time, which gives a good view on the current issues surrounding nutrigenomics. However, the relative impact of different expert groups on shaping overall consumer opinions towards nutrigenomics science and its applications is an issue that deserves further exploration. Case studies on various successful and unsuccessful technology introductions might be an appropriate research design to explore these relative impacts. Also, the extent to which experts agree or disagree with each other might be subjected to change over time. Therefore, it would be interesting to perform a follow-up study to examine the possible change in the level of consensus that exists among experts.

Third, we argued that nutrigenomics is an example of an innovation for which consumers have no proper frame of reference to judge it in. Therefore, we chose to use experts' points of view to get a clear overview of the predictors of public acceptance. Because we combined the insights of a broad spectrum of experts, we believe to have included as many angles as currently possible. Nevertheless, the analysis of the market chances for nutrigenomics is not completed yet, as the consumer, who will always be the ultimate judge of acceptability, could not be included. For long-term uptake of an innovation, it is important that all stakeholders participate in designing or adapting the innovation to their own purposes. Stakeholders are those people or groups with a vested interest in a particular product, service, or technology. This includes both those who design and implement – experts – and those who use – lay people – all with their own specific interest (Green & Kreuter, 2005). Now that we have an overview of how experts see the future of nutrigenomics, interesting and useful further research would be to take this knowledge to the public.

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5

CONSUMER ACCEPTANCE OF NUTRIGENOMICS-BASED PERSONALISED NUTRITION

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Introduction

Food intake, or more specifically nutrient exposure, is a key environmental factor that affects health status and performance (German et al., 2004). Since their origination, nutritional sciences have shaped our understanding of optimal levels and combinations of nutrients for health maintenance. Until recently, the focus has been on the discovery of substances in the diet and the mechanisms through which they function (Mehrotra, 2004), resulting in, for example, recommended daily intakes for various nutrients. As people consume foods rather than nutrients, these advices have been translated into food choice recommendations (e.g. the Food Guide Pyramid), which are to a large part assumed to be suitable for the entire population (Kussman, Raymond, & Affolter, 2006), with the exception of specific recommendations for groups like the elderly, pregnant women, infants, or athletes.

Despite its paramount importance for public health in general, limitations of this population-based approach are clearly demonstrated by the substantively different responses individuals can show to a given diet (Hesketh et al., 2006; Mutch, Wahli, & Williamson, 2005). Inspired by the successful completion of the Human Genome Project (McPherson et al., 2001; Venter et al., 2001), some have argued that nutrition research is now at the verge of a revolution, moving beyond general dietary recommendations towards personalised dietary advice (German & Watzke, 2004; Mehrotra, 2004; Mutch et al., 2005). The line of reasoning is as follows: (1) gene expression and metabolic responses at cellular level underlie health status, (2) gene expression and metabolic responses are the result of an interaction between genotype and environment (including nutrients), and thus (3) understanding the gene-nutrient interactions might open up the way for personalised nutrient intake recommendations based on an individual’s genetic constitution. In scientific terms, understanding the fundamental molecular and metabolic processes affected by foods (*nutrigenomics*) not only leads to insight into the mechanisms of health and disease, but can also enhance the predictive validity of assessing the genetic make-up for susceptibility to health and disease (*nutrigenetics*).

Hence, personalised nutrition for individual health management, disease prevention and performance improvement is a potentially promising deliverable from the genomics revolution in nutritional sciences (Kussman et al., 2006). It might provide individuals at high risk for metabolic diseases with specific nutritional advice, thereby maximising the efficacy of preventive measures (Joost et al., 2007). Scholars in the field, however, differ considerably in their optimism for these personalised diets for the overall population to emerge. Critical considerations about the promising future of personalised nutrition have been formulated from various angles and seem to cluster around three themes.

First, scientific and technological drawbacks of personalising nutrition have been expressed. The fact that genetic information, together with better early detection methods, can add to disease prevention is not disputed, but personalised nutrition as a goal is expected to be far ahead in the future (Hesketh et al., 2006). Present limitations include our incapacity to define optimal health or its key early biomarkers, and the necessity of large cohort studies which are hampered by the massive amount of phenotypic, genotypic, nutritional and other life-style information needed (Hesketh et al., 2006). Furthermore, as the genome, health, disease and the diet all are very complex and interactive, causality of certain genetic variations for disease will be difficult to prove and reproducibility of results a struggle (Katan, 2006). A technical hurdle that needs to be overcome are the high standards nutrigenomic foods should meet like controlled ingredient composition, the ability to be integrated into many food forms, good sensory qualities, and so on (Sutton, 2007).

Second, the possibilities for personalised nutrition are questioned from a marketing perspective. Genetics-based personalised nutrition is not likely to reach mainstream food market any time soon, as for the customer its benefits are currently outweighed by its costs in terms of privacy protection. Also, for food companies the additional costs of production, marketing, and distribution of personalised products for increasingly small consumer segments are not accountable yet (van Trijp & Ronteltap, 2007). Much of current segmentation in the food market is based on phenotypic information, so marketing potential of genotype-personalised nutrition should be assessed by examining its added value over phenotype as the segmentation basis. Crucial are the predictive ability of the genotype for disease development, and the extent to which the effect of genes can be altered by nutrition. Both seem to be limited at this point in time, especially for multi-factorial diseases such as diabetes and obesity (Kutz, 2006; van Trijp & Ronteltap, 2007).

Third, consumer acceptance of nutrigenomics and personalised nutrition is under discussion. Nutrigenomics may raise consumer worries regarding the rather instrumental approach to foods – generally an intimate part of people's daily lives with an important hedonic value (German & Watzke, 2004). Furthermore, perceived unnaturalness of (nutri-) genomics technology, privacy issues and control over sensitive information may become sources of concern. Research among Canadian consumers showed that genomics related to food evoked strong associations with genetic modification of crops and foods, e.g., Golden Rice (Burgess, 2003). Given the current status of other technologies somehow related to genes in Europe (e.g. plant biotechnology and stem cell research) (Joost et al., 2007), such associations might not be a good omen for public acceptance of nutrigenomics and personalised nutrition.

Consumer acceptance of personalised nutrition has received very limited research attention (van Trijp & Ronteltap, 2007). This is not surprising given the fact that it is unclear how nutrigenomics spin-offs like personalised nutrition will take shape exactly. At the same time, incorporating consumer preferences and concerns in the early stages of the new product development process has been identified as a critical success factor for technology (Frewer,

2003) and new product development (van Kleef, van Trijp, & Luning, 2005). So, anticipatory consumer research can help shape the development of the technology to optimise potential spin-offs.

This study takes a consumer research approach in the context of genomics-based personalised nutrition. Appreciating that the specific characteristics of this new technology have not crystallised out yet, our study takes more abstract consumer perceptions as its starting point. This is consistent with temporal construal theory (Liberman & Trope, 1998; Trope & Liberman, 2000) which shows that in their evaluation processes consumers tend to represent situations that are psychologically more distant in time at a more abstract level. Hence, representing potential futures of personalised nutrition in concrete features would not fit with how people conceive of and evaluate them. Building on previous research (Ronteltap, van Trijp, Renes et al., 2007), we investigate the effects of consumer perceptions of personalised nutrition on preference as a measure of acceptance, and through which mechanisms these effects come about. The structure of the paper is as follows. First, using the personalisation and innovation literature we build a conceptual framework from which we develop specific hypotheses. We then test the hypotheses in a large-scale consumer study using an innovative research approach. Besides the effects of consumer perceptions of personalised nutrition on preference, we investigate whether distinct consumer groups can be identified with respect to their preferences for personalised nutrition. Results are described and interpreted, and we conclude with implications for the nutrigenomics field.

Theoretical background

Personalised nutrition constitutes an innovation in the food market. Not only does it reflect the state of the art in nutritional sciences called nutrigenomics, it is also in line with the trend of personalisation in food marketing more generally (Sutton, 2007). In many different domains personalisation, defined as the process of adjusting marketing offerings to the identified needs of customers (van Trijp & Ronteltap, 2007), is considered a promising strategy as it adds value to both the customer and the supplier. Value to customers is achieved by a better match of offerings to their idiosyncratic rather than average need structures, and to suppliers by increased price premiums and customer loyalty, and by differentiation from competitors that still focus on mass marketing (Vesanen, 2007).

As to the current personalised nutrition market, two types of products are of interest: diagnostic tests and products based on those tests, be it nutritional advice or food products (Oliver, 2005). Various companies are selling DNA-based tests at the moment, some of them also offering dietary supplements or even personalised behavioural recommendations based on their genetic make-up and current eating and lifestyle habits. Due to the current state of science, these dietary advices are rather general in nature and do not provide extensive guidelines about what to eat and what to avoid. To the best of our knowledge, personalised food products based on consumers' DNA are not yet marketed. Truly personalised nutrition is still years ahead of us, and there is no shared view about the future of personalised nutrition, as evidenced by the spectrum of speculations. One possibility is put forward by Joost et al (2007), expecting that personalised nutrition will not be using full, individual genomic information, but will rather be targeted at families. A second operationalisation could be the production of functional foods, nutraceuticals, and supplements with improved substantiation of health claims using genomic knowledge (Castle, 2007). The most dramatic example of personalisation is described by Sutton (2007), as the use of point-of-sale technologies where a product (e.g. a beverage) could be prepared using a combination of ingredients to suit an individual's genotype.

Consumer perceptions

As there is still no agreement on how personalised diets will take form, it makes no sense to investigate consumer acceptance at the level of concrete descriptions. Following the principles of temporal construal theory (Trope & Liberman, 2000), it is more sensible to use consumer perceptions at a more abstract level for understanding acceptance at this point in time. Consumer acceptance of innovations, such as personalised nutrition, can be partly explained by consumer characteristics, the perceived characteristics of the innovation, and the communication that accompanies the innovation (Rogers, 2003).

As to communication, several aspects are of particular interest. Nutrigenomics and personalised nutrition are new and unknown phenomena, which makes consumers more dependent on how and what experts communicate about them. Concerning *how* is being communicated, objects or events can be described in either positive or negative wording while representing objectively equivalent descriptions. This is called attribute framing and the consensus finding is that positive frames lead to more positive object evaluations than those with a negative framing (Levin, Schneider, & Gaeth, 1998). In the present context, nutrigenomics-based personalised nutrition may be communicated positively in terms of health and performance enhancement at later life stages, or in terms of a reduction of (risk of) disease. Our first hypothesis is thus:

> *H1: Compared to negatively framed communication, positively framed communication about personalised nutrition will have a positive effect on consumer acceptance*

Whereas framing is about *how* personalised nutrition is being positioned in the market place, another aspect of communication is *what* is being communicated. Previous research has suggested that in general, receiving conflicting information from different sources would lead to social uncertainty (Dean & Shepherd, 2007; Einhorn & Hogarth, 1985). People prefer consensus messages, even when they are ambiguous, to conflicting ones (Smithson, 1999).

Therefore, we expect that a high level of agreement among experts communicating about nutrigenomics and personalised nutrition will enhance consumer acceptance of personalised nutrition.

H2: Agreement among experts about the promise of personalised nutrition will have a positive effect on consumer acceptance

In terms of innovation characteristics, of the many features that have been studied previously, perceived usefulness and ease of use are consistently reported as the strongest determinants of public acceptance of innovation (Tornatzky & Klein, 1982). This is also confirmed in the rich literature on the Technology Acceptance Model (Lee et al., 2003; Venkatesh et al., 2003). Perceived usefulness is defined as the degree to which an individual believes that using an innovation is beneficial for achieving desired goals. Translated to personalised nutrition, it is the extent to which consumers perceive personalised nutrition to deliver benefits, either to themselves or to another group in society. If personalised nutrition is perceived to be personally relevant and useful to the consumer, this will lead to more rapid adoption of the innovation (Rogers, 2003). Also, previous research has shown that acceptance of nutrigenomics products and services may be hampered by consumers' suspiciousness towards commercial interests (van Trijp & Ronteltap, 2007), so we expect that:

H3: If personalised nutrition is perceived to be personally relevant and useful in delivering benefits to the consumer, this will have a positive effect on consumer acceptance

H3a: If personalised nutrition is perceived to deliver benefits primarily to industry, this will have a negative effect on consumer acceptance

Ease of use expresses the extent to which an innovation is perceived to be difficult to understand and use. In terms of personalised nutrition, ease of use stands for the amount of effort people have to invest to implement personalised nutrition in their daily lives. Think for example of the family dinner, if nutrigenomics actually leads to individualised meals this implies quite some extra work at household level. Similarly to usefulness, perceived ease of use increases the speed of adoption of an innovation (Rogers, 2003).

H4: If personalised nutrition is perceived as easy to use and implement in lifestyle, this will have a positive effect on consumer acceptance

In the context of genomics-based personalised nutrition, one factor of particular importance is the sensitivity of genetic information in relation to privacy concerns. In order to draw up personalised dietary advice based on a person's genes, it is inevitable to have his or her genetic makeup profiled. A person's genetic makeup is personal, stable over time, and may indicate susceptibility for various disorders. Because DNA samples can be held indefinitely, the risk exists that they will be used for purposes other than those for which they were gathered. Genetic information is potentially interesting to several third parties, for example insurance companies, which might use it to deny insurance policies, employers, who can use it to screen potential employees, or the government, who can use it for screening and health promotion purposes. Hence, consumers may be reluctant to make that necessary genetic information accessible. This may induce a reduction of consumers' (perceived) freedom of choice. Freedom of choice, or autonomy, has been identified as an important basic need for well-being of all people, regardless of gender, group, or culture (Deci & Ryan, 2000). Furthermore, reactance theory states that threats to freedom reduce the effectiveness of social influence and create resistance to persuasion (see, e.g., Silvia, 2006). So we anticipate that:

H5: If consumers are allowed freedom to choose to have their genes profiled, this will have a positive effect on consumer acceptance for personalised nutrition

To summarise, we identified five consumer perceptions of personalised nutrition that we expect to be important for consumer acceptance. These factors are in line with previous research among expert stakeholders in the field of nutrigenomics that identified inhibiting and promoting factors for the development of nutrigenomics (Ronteltap, van Trijp, & Renes, 2007).

Psychological processes

The consumer perceptions of personalised nutrition exert their effect on consumer acceptance through an identified set of psychological processes that determine consumer acceptance of food innovations more generally. This set of psychological constructs consists of cost-benefit assessment, perceived risk and uncertainty, perceived behavioural control and subjective norm (Ronteltap, van Trijp, Renes et al., 2007). The trade-off between costs and benefits stems from the traditional economic approach to acceptance of technological developments in society (Starr, 1969) and is also prominent in the attitude literature as the pros and cons of conducting the behaviour (Fishbein & Ajzen, 1975). Behaviours that have a positive benefit to cost ratio are more likely to be engaged in. In contrast to other innovations, foods are actually ingested into the human body (Rozin, 1999), which makes them very prone to generate perceptions of risk and uncertainty. Whether a person believes he or she can actually perform the behaviour necessary for innovation acceptance is called perceived behavioural control, which has long been identified as a determinant of behaviour, together with subjective norm (i.e. whether significant others are likely to endorse the behaviour) (Ajzen, 1991). These four processes have been proposed to mediate the effects of consumer perceptions of personalised nutrition on consumer preferences and thereby on acceptance (see Figure 5.1).

The consensus finding in psychological framing theory (Levin et al., 1998), namely that positive framing of a message (i.e. using positive rather than negative wording for equivalent options with respect to message content) leads to more positive consumer evaluations than

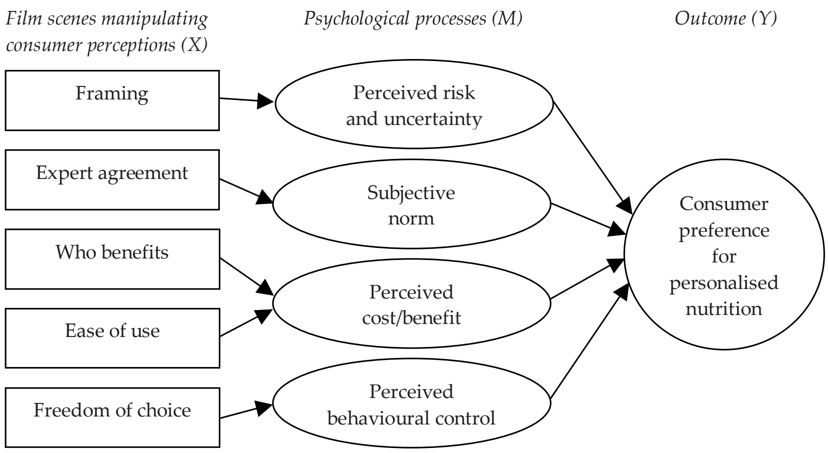

Figure 5.1. Theoretical model

negative framing, is attributed to the fact that positive wording makes accessible in memory a broader range of positive associations and that these positive feelings are subsequently mapped onto evaluations of the message (the valence consistent shift) (Levin et al., 1998). In the present context, expressing the benefits of personalised nutrition with a focus on delay of onset and even prevention of disease is more likely to make disease-related associations accessible from memory and hence negative emotions. On the other hand, positive communication about personalised nutrition with an emphasis on maintenance of good health communicated with a clear and simple message on its benefits is more likely to make positive feelings accessible (Mehrotra, 2004). In positive moods consumers are less likely to engage in systematic processing such as cost benefit analysis (Bagozzi, Gopinath, & Nyer, 1999), and more likely to follow a low elaboration affective route such as through risk and uncertainty perceptions.

H6: The positive effect of positively framed communication on preference is primarily mediated by reduced levels of risk and uncertainty

As with many influential innovations and nutritional innovations in particular, consumers have very limited ability to assess the true added value to quality of life from personal knowledge. To form beliefs about how credible and beneficial these developments are, they have to rely on information from others (Fishbein & Ajzen, 1975). In the context of nutrition, direct peers, like family and friends, are not a very informative source of information leaving consumers reliant on nutritional experts to advice their decision. In line with Figure 5.1, we expect that the effects of expert opinion on the feasibility and desirability of personalised nutrition will exert its effect through subjective norm: the extent to which relevant others endorse the commitment to personalised diets. If nutritional experts are in agreement about the benefits of personalised nutrition, there will be a consistent effect through subjective norm.

H7: The positive effect of agreement about personalised nutrition among experts on preference is primarily mediated by directive and positive subjective norm

Several groups in society may benefit from the transition towards personalised nutrition. From a consumer perspective the benefit directly impacts the cost-benefit ratio. If for the consumer the benefits are perceived to outweigh the costs this will enhance acceptance of personalised diets. On the other hand, usefulness of personalised nutrition may also be expressed as benefits to the industry (a commercial benefit) or to the advancement of nutritional sciences more generally. The distribution of costs and benefits of personalised diets may be skewed; they require an investment (both monetary and non-monetary) on the part of the consumer, while benefits may accrue to other stakeholder groups like the food industry. Hence, we expect that perceived usefulness in terms of beneficiary stakeholder group will exert its effect primarily through the psychological process of cost-benefit consideration.

H8: The positive effect on acceptance of the consumer as main beneficiary of personalised nutrition is primarily mediated by a positive outcome of considerations of benefits vs. costs

In the present case, ease of use is the extent to which personalised diets are perceived as being compatible with current food habits and easy to implement in consumers' existing lifestyles. Whereas usefulness directly relates to the benefits inherent in personalised nutrition, ease of use more directly relates to the perceived (non-monetary) costs of adopting personalised diets. If personalised nutrition integrates smoothly into existing eating habits, it is easy to implement in daily life, which reduces the perceived costs of the innovation.

H9: The positive effect of ease of use on acceptance is primarily mediated by a positive outcome of considerations of benefits vs. costs

As argued previously, the extent to which consumers are free to choose whether or not to make their genetic profile available is expected to be a key determinant of consumer acceptance of personalised nutrition. In general, consumers in western societies put high value on independence and freedom of choice as this enhances their perception of autonomy (Deci & Ryan, 2000). In terms of Figure 5.1, we therefore hypothesise that freedom of choice for having the genetic constitution profiled and registered (as opposed to being obliged to do so by for example the government) will strongly prompt consumer perceptions of the control they have over their behaviour. Hence:

H10: The positive effect of freedom of choice on acceptance is primarily mediated by a higher perception of behavioural control

All our hypotheses focus on generic processes to explain how consumer perceptions of personalised diets affect consumer acceptance. However, in these processes, consumers may differ in the extent to which they value each of the perceptions to arrive at a personal acceptability of personalised diets. As to our knowledge there is no previous research on consumer segmentation in acceptance of alternative operationalisations of personalised nutrition, we also conduct an exploratory segmentation analysis. The aim of this segmentation is to explore sensible sub-groups of consumers with similar preferences for personalised nutrition operationalisations.

Methodology

As personalised nutrition is in an early stage of development, consumers may have difficulties imagining it. To provide consumers with an adequate context, we used an innovative research method in which consumers evaluate systematically varied scenarios of how genomics-based personalised nutrition might develop in the future. Inspired by techniques like information acceleration (Urban, Weinberg, & Hauser, 1996), we provide these scenarios to consumers as short films rather than 'cold' words to enhance the validity of the consumer evaluations.

Stimulus material

Our model distinguishes between five consumer perceptions all but one at two levels (in parentheses): message framing (positive vs. negative), agreement between experts (consensus vs. dissensus), beneficiary stakeholder group (consumer vs. science vs. industry), ease of use (easy vs. complex), and freedom of choice (freedom vs. coercion). For each of these levels concise verbal scripts were written by the authors (see Appendix A) on the basis of which the Utrecht School of the Arts produced eleven (4x2 + 1x3) short (average length of 39.5 seconds) film scenes. Prior to assembling these film scenes into systematically varied five-scene films (the number of consumer perceptions), they were pre-tested in a pilot study.

Pilot study

To verify the validity of the film scenes as experimental manipulations of the different levels of the consumer perceptions, a quantitative pilot study was conducted with a sample of 92 respondents, 51% males, average age of 30.5 (SD=6.1 years). Each respondent rated all 11 scenes in randomised order on a set of 16 items (see Table 5.1) using 9-point Likert-type scales. Table 5.1 shows the mean ratings for the relevant items per scene[8]. Respondents perceived all scenes as realistic as evidenced by the average score of 6.4 (range= 5.3 – 8.0) on the item "I had no trouble imagining this film was real". Table 5.1 further reveals that the film scenes

[8] Full results are available from the corresponding author. Analysis of non-targeted items (e.g. rating of ease of use for framing manipulation) showed no consistent patterns.

adequately represented the intended levels of consumer perceptions, although for message framing we found less strong support (p<.10).

Table 5.1. Mean scores for manipulation check items in pilot study

Consumer perception of personalised nutrition Item (measured on 9 point scales)	Levels manipulated in film scenes		
Message framing	**Positive**	**Negative**	
Is film focused on achieving positive events?	8.1[c]	7.5[d]	
Is film focused on preventing negative events?	6.2[c]	7.2[d]	
Had no trouble imagining the film was real	*7.3*	*6.4*	
Agreement	**Consensus**	**Dissensus**	
Do experts agree?	7.6[a]	2.4[b]	
Do experts share the same opinion?	7.5[a]	1.8[b]	
Had no trouble imagining the film was real	*5.4*	*5.9*	
Which group benefits	**Consumer**	**Science**	**Industry**
Do consumers benefit primarily from personalised nutrition?	7.6[a]	6.8[ab]	6.1[b]
Do scientists benefit primarily from personalised nutrition?	6.8[c]	7.9[d]	6.9[c]
Does industry benefit primarily from personalised nutrition?	7.0[a]	6.9[a]	8.2[b]
Had no trouble imagining the film was real	*8.0*	*7.2*	*6.6*
Ease of use	**Easy**	**Complex**	
How much effort does personalised nutrition cost?	3.0[a]	6.8[b]	
How easy is personalised nutrition to implement in daily life?	7.9[a]	2.4[b]	
Had no trouble imagining the film was real	*6.3*	*5.9*	
Freedom of choice	**Freedom**	**Coercion**	
Do consumers have freedom of choice in having genetic data examined?	6.7[a]	2.8[b]	
Are consumers forced to have genetic data examined?	3.8[a]	7.5[b]	
Had no trouble imagining the film was real	*6.4*	*5.3*	

Differences between mean values are examined per item through t-tests or F-test (for which group benefits only) with Tukey HSD Multiple Comparison Test.

[a,b] *Mean values with unlike superscript letters were significantly different at the p<.05 level.*

[c,d] *Mean values with unlike superscript letters were significantly different at the p<.10 level.*

These results provided a good basis for use of the filmed material in the main study. The film scenes were combined to form various possible descriptions of the future of personalised nutrition. Each combination of 5 scenes (one level of each of the 5 perceptions) will be called a 'profile' from here on. An example of a possible profile in key words is shown in Box 5.1, with the ingredients of the full text provided in Appendix A.

Box 5.1. Profile Example

The framing of communication to the consumer is positive;
There is agreement among stakeholders about the meaningfulness for society;
Scientists are the group that benefits from personalised nutrition;
Personalised nutrition is easy to use for the consumer;
There is no freedom of choice for the consumer.

Data collection procedure

Design. A systematically varied design was used to determine consumers' preference structure for personalised nutrition. With 5 scenes, one with 3 levels and four with 2 levels, the total number of possible profiles (i.e. different 5-scene combinations) would be 48 (3*2*2*2*2). To minimise information overload and fatigue, a fractional factorial main effects design was used to reduce the profiles to 8 while maintaining orthogonality of the factors. In marketing research this methodology is known as conjoint analysis and is widely applied both in scientific (Green & Srinivasan, 1990) and commercial studies (Wittink & Cattin, 1989). Based on the fractional factorial design with scene levels, coded as dummy variables, serving as independent variables individual-level linear regression models are estimated across the 8 so-called calibration profiles with preference as the dependent variable. The fit of these linear regression models is estimated as the correlation between predicted preferences from the linear regression model with the actual preference ratings provided by the respondent. Predictive validity of the individual level linear regression models is assessed for three so called hold-out profiles which are also rated on preference by the respondents but not incorporated in the estimation of the regression parameters. Predictive validity with three hold out profiles can be assessed from the regression model's ability to correctly predict the highest preference from among the three hold out profiles (percentage of correctly predicted first choice).

The participants were randomly assigned to one of eight blocks, each block having a unique set of holdout profiles to increase variability in our study. As a warm up and to familiarise respondents with the task, each respondents first evaluated one standard reference profile before evaluating the 8 calibration profiles, and 3 holdout profiles, randomly chosen per block. The order of the profiles was randomised per set of 8 calibration profiles and per set of 3 holdout profiles, and scenes within the profiles were shown in random order to prevent predictability and thereby loss of attention of respondents.

Sample. The data were collected between November 2006 and February 2007 by a professional marketing research agency. Respondents were approached by telephone at random and sampled on the basis of their age, gender, education, family size, and region of residence, in order to arrive at a quota sample representative for the Dutch population. A total of 643 respondents were invited to visit the nearest of 18 test facilities to participate in the study, of which 438 (68%) successfully finished their participation. The remaining 205 either did not show up (N=175) or experienced technical difficulties with computers used for the research (N=30). A comparison between the Dutch population and our sample (see Table 5.2) with respect to the demographic data shows a good match with some minor differences. The sample distribution is equivalent to the population distribution in terms of gender ($\chi^2_{(df1)}$=0.17; ns) and regional spread ($\chi^2_{(df4)}$=3.27; ns) but there is a slight underrepresentation of single person households ($\chi^2_{(df2)}$=34.52; $p<0.05$) and a slight overrepresentation ($\chi^2_{(df4)}$=54.46; $p<0.05$)

of respondents in the age category 40-64 yr and respondents with higher education ($\chi^2_{(df2)}$=66.68; p<0.05). However, we have no reason to assume these small differences to influence interpretation of our results.

Table 5.2. Study sample characteristics compared to the Dutch population in 2006

	Sample (%) (N=416)	Population (CBS, 2006) (%)
Gender		
$\chi^2_{(df1)}$= 0.17		
male	48	49
female	52	51
Age		
*$\chi^2_{(df4)}$= 54.46**		
<20	4	7
20-39	24	33
40-64	54	42
65-79	18	13
≥80	-	4
Household size		
*$\chi^2_{(df2)}$= 34.52**		
1 person	21	35
2 persons	41	33
> 3 persons	38	33
Education		
*$\chi^2_{(df2)}$= 66.68**		
low	20	34
middle	39	40
high	41	25
Nielsen regional spread		
$\chi^2_{(df4)}$= 3.27		
1 3 big cities	15	16
2 rest West	34	30
3 North	9	10
4 East	20	21
5 South	22	23

* *p<0.05*

Protocol. Respondents were invited to one of 18 test facilities, spread over the Netherlands. After a group introduction, in which the host stressed that the scenarios in the study take place in the future (2015), respondents participated individually on a laptop wearing headsets. They were given on-screen instructions to carefully watch and listen to each scenario and answer questions about the scenarios. It took them on average 69.7 minutes (SD 8.8 minutes) to complete the test, with a 5-minute break in the middle of the test to prevent severe fatigue. Afterwards, respondents were debriefed and given a monetary compensation for their participation.

Measurements

As a measure for acceptance, the key dependent variable was preference, measured with a three-item semantic differential scale (α=.97) based on Bredahl (2001) (in Laros, 2006). End poles of the 7 point semantic differential scales were labelled "bad-good", "unappealing-appealing" and "negative-positive", respectively. For further analysis, the scores on the three items were averaged, the key dependent variable in this study thus ranging from 1 to 7. For the psychological processes of cost-benefit assessment, perceived risk and uncertainty, perceived behavioural control and subjective norm 1-item 7-point Likert-type measures were used with end poles labelled "disagree" (1) and "agree" (7). The items were selected from previous research (Ronteltap, Renes, & van Trijp, in preparation) and selected as the best item from their respective multiple-item scales[9]. Risk and uncertainty were measured as two separate constructs, as the internal consistency of the scale combining both was very low. All items are listed in Table 5.3.

Table 5.3. Overview of items used in main study

Outcome measure (Y)
Preference
I think the development outlined in the film is
1 bad/good – 2 unappealing/appealing – 3 negative/positive
Psychological processes (M)
Perceived cost/benefit considerations
If I consider all pros and cons of the development outlined in the film, I am positive about it (disagree – agree)
Perceived risk
I have the feeling that the development outlined in the film brings about a lot of risk (disagree – agree)
Perceived uncertainty
My feelings tell me that the development outlined in the film leads to high uncertainty (disagree – agree)
Subjective norm
Most people who are important to me would be positive about the development outlined in the film (disagree – agree)
Behavioural control
If the future develops as in the film, I will have full control over the decision to participate in it (disagree – agree)

Data analysis

Examination of the dataset. Data were examined for any irregularities. Of the 438 respondents, 1 gave the same answer to *all* questions, and another 9 rated all 12 profiles with the same preference. In addition, their time spent on answering the questions was lower than average. These 10 respondents were excluded from further analyses as they did not perform their task

[9] In previous research, these multi-items scales showed adequate internal consistency: Cost-benefit assessment (3 items, α=.88), Perceived risk and uncertainty (3 items, α=.73), Perceived behavioural control (4 items, α=.76), Subjective norm (2 items, α=.58).

seriously. The correlation between the measured and the predicted preference scores for the 8 calibration profiles, expressed as Pearson's R, was not significant for another 12 cases, meaning that the estimated regression model did not adequately represent those respondent's data. Dropping this group leaves a final sample of 416 respondents.

Mediation analysis. To examine whether the psychological processes, perceived risk, perceived uncertainty, subjective norm, perceived cost/benefit and perceived behavioural control (denoted M in Figure 5.1) mediate the effect of the consumer perceptions (operationalised in film scenes and denoted X in Figure 5.1) on consumer preference for personalised nutrition (denoted Y in Figure 5.1), a standard mediation analysis was performed (Baron & Kenny, 1986). Perfect mediation is demonstrated if the independent variables (film scenes X) exert significant effects on the mediator (psychological processes M) as well as the dependent variable (consumer preference Y) but the effect of the independent variable on the dependent variable becomes non-significant when the mediating variable is incorporated as a covariate. If the effect remains significant but the effect size significantly reduces, partial mediation is demonstrated. Mediation is formally tested through a set of regression equations, namely: (1) Y=f(X), (2) M=f(X), and (3) Y=f(M,X), with the size of the regression parameter for the independent variables being compared between models (1) and (3). Note that X is measured as dummy variables (0-1), and M and Y on a scale ranging from 1 to 7.

Heterogeneity in consumer preference. To explore the possibility that consumers may not be homogeneous with regard to their preference structure for different operationalisations of personalised nutrition as evidenced in the filmed scenarios (Y=f(X)), a finite-mixture regression model was estimated following the principles of market segmentation proposed by Wedel and Kamakura (2000). Finite mixture modelling provides techniques to partition data into homogeneous subgroups and simultaneously perform regression analyses within each group. The software package Glimmix 2 was used, which allows for the simultaneous estimation of respondent segments and regression models to explain preference per segment. Preference ratings were centred to prevent a segmentation based on the value of the mean. As Glimmix gives probabilities of respondents' membership of segments instead of strictly assigning them to one particular group, the posterior probabilities were used to assign respondents to one segment exclusively for further examination of the segments.

Results

An average Pearson's R of .951 (ranged .656 - 1.000, SD .062) between model-predicted and actual preferences showed an excellent fit of the model for the calibration profiles. In addition, the correlation coefficient between the average measured preference for all profiles included in the study against the average predicted preference was .96, so the conjoint model was also able to predict consumer preference for all profiles on group level very well. The predictive ability of the conjoint model for the holdout profiles on an individual level, measured by the percentage correctly predicted first choice[10], was 47.6%, which is significantly higher than the 33.3% correct predictions that could be expected based on chance. These results show that the conjoint model performed very well on an aggregate level and acceptably on an individual level.

Mediation by psychological processes.

The results of the mediation analysis[11] are displayed in Table 5.4, of which the columns indicate the different models estimated in the steps of the mediation analysis.

Table 5.4. Mediation analysis: effects on preference (Y) expressed as unstandardised regression coefficients

Model →	*1* perceptions	*2* processes	*3* perceptions + processes	*4* cost/ benefit	*5* risk	*6* uncer- tainty	*7* subjective norm	*8* control
Film scenes (X)								
pos framing	.026		.024	.028	.013	.015	.025	.038
agreement	.326**		.084**	.118**	.259**	.270**	.165**	.288**
consumer benefit	.275**		.089**	.112**	.223**	.227**	.172**	.224**
science benefit	.291**		.115**	.123**	.252**	.256**	.200**	.263**
ease of use	.281**		.122**	.105**	.320**	.283**	.162**	.291**
freedom	.822**		.073*	.225**	.707**	.736**	.378**	.233**
Psychological processes (M)								
cost/ benefit		.532**	.519**	.714**				
risk perception		-.075**	-.076**		-.304**			
perceived uncertainty		-.042**	-.040**			-.264**		
subjective norm		.231**	.225**				.618**	
behavioural control		.066**	.060**					.316**
R^2	$.150^a$	.665	$.670^b$	$.625^b$	$.238^b$	$.221^b$	$.471^b$	$.285^b$

**Significant at p < .05, **Significant at p < .01.*

[a, b] Unlike superscript letters indicate a significant (p<.001) increase in R^2 relative to model 1 with the inclusion of the mediating variable(s).

[10] This measure expresses the extent to which the model is able to correctly predict which of the three holdout profiles rated by each respondent is preferred most. Because of the presence of ties in both the actual and predicted preference scores, all first-choice indices have been adjusted to allow for multiple first-choice hits. For example, if a respondent prefers 2 profiles most and equally, while the model predicts only one of those two profiles to be preferred most, the first-hit index was recorded as .5 instead of 1.0 (similar to Green & Schaffer, 1991).

[11] A condition for mediation is that the consumer perceptions and the mediators (the constructs) are correlated. A MANOVA resulted in models that explained 13.3% of variance in cost/ benefit perceptions, 3.6% of variance in risk perception, 2.5% of variation in perceived uncertainty, 10.9% of variance in subjective norm, and 29.2% of variance in perceived behavioural control. All effects of the consumer perceptions on the constructs for which we formulated specific hypotheses (H6-10) were significant at p<.05, except for all effects of message framing.

In model 1 (Y=f(X)), preference was explained by dummies of the film scenes manipulating the consumer perceptions (R^2=15%). All perceptions except framing contributed significantly to explaining preference, with freedom of choice as the strongest contributor. As hypothesised, consensus among experts (b=.326), benefits for consumers (b=.275) or science (b=.291), personalised nutrition being easy to use (b=.281), and consumer freedom of choice (b=.822) had a positive effect on preference compared to their counterpart-levels (p<.01). This implies that we found no support for hypothesis 1, strong support for hypotheses 2 to 4, and very strong support for hypothesis 5.

The second model (Y=f(M)), exploring the effects of the psychological constructs on preference, explained 66.5% of variance in preference. A positive outcome of benefits against costs (b=.532), a strong perception of subjective norm (b=.231), and a high behavioural control perception (b=.066) influenced preference positively, while risk (b=-.075) and uncertainty (b=-.042) perceptions affected preference negatively (p<.01). All processes contributed significantly, but cost-benefit considerations was clearly the strongest contributor. Model 2 lent strong empirical support to the conceptual model used in this study (Figure 5.1).

Model 3 (Y=f(X,M)) included both the film scenes and the psychological constructs to explain preference. The explained variance of this model was 67.0%, and all predictors had a significant effect at 5%, except for message framing. The considerable drop[12] in regression coefficients of the film scene perceptions in model 3 compared to model 1 showed (partial) mediation of the film scene perceptions by the psychological constructs. To examine which of the constructs mediates which film scene perception effect (Hypotheses 6-10), the models 4-8 were estimated (see Table 5.4). In model 4, cost-benefit considerations was added to the film scenes as predictor of preference. In model 5, risk perception was added, in model 6 perceived uncertainty, in model 7 subjective norm, and in model 8 perceived behavioural control.

The effect of message framing on preference was not significant, but as hypothesised (H6), its regression coefficient decreased when risk (model 5) or uncertainty (model 6) were added. Therefore, we found directional (but insignificant) support for hypothesis 6. The effect of agreement among experts was expected to be mediated primarily by subjective norm, which was indeed the case (see model 7), so hypothesis 7 is supported. Moreover, model 4 showed that cost-benefit considerations also mediated the effect of agreement partially. In support of hypothesis 8, the effect of who benefits from personalised nutrition was mediated by a trade-off between costs and benefits (see model 4). Furthermore, the positive effect of the consumer as the main beneficiary of personalised nutrition was also partly mediated by subjective norm (model 7). In accordance with hypothesis 9, the effect of ease of use was mediated by a positive outcome of the trade-off between benefits and costs, but also by

[12] Please note that there is no formal statistical test to assess the size of the reduction in the regression parameters. This is a qualitative judgment, based on the ratio of the direct effect without versus with inclusion of the mediating construct.

subjective norm. The positive effect of freedom of choice was mediated by a higher perception of behavioural control, as shown in model 8, lending support for hypothesis 10. This effect too was partially mediated by cost-benefit considerations, and, to a lesser extent, by subjective norm.

In summary, we found strong support for all hypotheses except those related to message framing. Additionally, we found that many of the effects were also mediated by cost-benefit considerations, the most dominant of the psychological processes that determine consumer acceptance.

Heterogeneity in consumer preferences.

Multivariate normal mixture regression models with 2 to 7 classes[13] were fitted, with the film scenes as manipulations of consumer perceptions as predictors for preference. We selected the six-class solution which minimises the values of the Consistent Akaike Information Criterion (CAIC) and Bayesian Information Criterion (BIC). Table 5.5 shows the estimated regression coefficients for each of the six segments, expressed relative to their reference level. The segments are described by their mean demographics and the relative importance the segments attach to the psychological constructs mediating the effect on preference. The first segment consisted of nearly 6% of the sample, for which preferences for personalised nutrition were hardly influenced by any of the consumer perceptions. Also, none of the mediating psychological processes explained their preferences (R^2=0.027; ns). Consumers in this segment, have higher age on average (mean age=59 yrs), are mainly living in 2-persons households and have a relatively low education level. Preferences in segment 2 were significantly influenced by almost all consumer perceptions manipulated in the film scenes and particularly ease of use and freedom of choice. This segment was not driven by convenience as ease of use actually strongly (b=-.998) distracted from their preferences. For this segment, perceived risk was a significant predictor of preference. The segment's size was 16%, and it consisted of relatively few people with a 1-person household. The third segment (21% of the sample) attached a very high importance to ease of using nutrigenomics, and contained even fewer people who live alone. Cost-benefit trade-off was the dominant psychological construct for them. Segment 4 contained more males than females, and their preferences were very strongly driven by freedom of choice. Behavioural control was the psychological construct driving their preferences relatively strongly. This segment was characterised by a relatively high level of education. Compared to the total population, segment 5 was relatively insensitive to agreement among experts, ease of use and freedom of choice. Preferences of this segment, with a small majority of women, were poorly accounted for both in terms of consumer perceptions manipulated in the film scenes (R^2=.035) and mediating psychological constructs

[13] We ran the mixture regression model with 10 different start values to avoid solutions at local optima. The solutions were very stable.

(R^2=.143). Compared to the other segments, the profile of the last and largest (27%) segment deviates least from the overall population except that it consisted mainly of females with a relatively high level of education who attached an above average importance to behavioural control in their preference formation.

Table 5.5. Six-segment solution

	overall	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
N	*416*	17(4.1%)	67(16.1%)	86(20.7%)	71(17.1%)	64(15.4%)	111(26.7%)
Scenes (b)							
positive framing	*.026*	-.013	.383**	-.098	-.071	-.021	-.005
agreement	*.326***	-.022	.633**	.349**	.364**	.064*	.279**
consumer benefit	*.275***	.000	.211	.508**	.475**	.103**	.129*
science benefit	*.291***	-.025	.540**	.337**	.422**	.095**	.169**
ease of use	*.281***	-.012	-.998**	1.589**	.401**	.021	.145**
freedom of choice	*.822***	.010	.916**	.352**	2.835**	.030	.437**
$R^{2\dagger}$	*.150*	.053	.352	.345	.681	.035	.129
Time spent (min) $F_{(df5)}=2.14$	*69.77*	72.34^{ab}	71.08^{a}	71.39^{a}	67.94^{b}	68.73^{ab}	69.09^{ab}
Age (yrs) $F_{(df5)}=1.47$	*48.9*	58.7^{a}	48.7^{b}	49.5^{b}	46.9^{b}	48.7^{b}	48.7^{b}
Gender (%) $\chi^2_{(df5)}=36.90$**							
male	*48.3*	52.9	47.8	53.5	57.7	45.3	39.6
female	*51.7*	47.1	52.2	46.5	42.3	54.7	60.4
Household size (%) $\chi^2_{(df10)}=161.7$**							
1	*21.2*	25.0	19.4	12.8	22.5	28.1	23.4
2	*40.7*	62.5	40.3	40.7	40.8	34.4	41.4
≥ 3	*38.1*	12.5	40.3	46.5	36.6	37.5	35.1
Nielsen region (%) $\chi^2_{(df20)}=157.4$**							
3 big cities	*15.1*	11.8	11.9	12.8	16.9	15.6	18.0
rest of West	*33.9*	17.6	37.3	31.4	40.8	40.6	27.9
North	*9.4*	11.8	10.4	11.6	14.1	3.1	7.2
East	*20.2*	29.4	20.9	19.8	9.9	20.3	25.2
South	*21.4*	29.4	19.4	24.4	18.3	20.3	21.6
Education (%) $\chi^2_{(df10)}=163.9$**							
low	*19.6*	21.4	16.7	22.8	16.4	21.7	19.4
middle	*39.2*	64.3	45.0	39.2	34.4	36.7	36.7
high	*41.1*	14.3	38.3	38.0	49.2	41.7	43.9
Psychological constructs (b)							
cost/benefit	*.532***	-.114	.557**	.613**	.546**	.227**	.478**
risk	*-.075***	-.058	-.132**	-.076*	-.027	-.076	-.064*
uncertainty	*-.042***	-.008	-.010	-.039	-.049*	-.099*	-.012
subjective norm	*.231***	-.038	.212**	.163**	.259**	.178**	.191**
behavioural control	*.066***	.115	.050	.039	.148**	.064	.117**
R^2	*.665*	.027	.672	.604	.870	.143	.444

**Significant at p<.05, **Significant at p<.01.*

[a, b] *Differences between segments were tested with F-tests for continuous variables (time spent, age) and χ^2-tests for nominal (gender, Nielsen region) and ordinal (education) variables. On continuous variables, segments with unlike superscript letters were significantly different (p<.05), examined through LSD Multiple Comparison Test.*

[†] *As Glimmix does not provide R^2-values per segment, these were calculated externally based on exclusive segment membership.*

Discussion

Despite widespread consensus on the potential of nutrigenomics research for understanding the mechanisms of health as affected by the diet, less agreement exists when it comes to the feasibility of nutrigenomics-based consumer applications (Ronteltap, van Trijp, & Renes, 2007). Scientific research on consumer acceptance of nutrigenomics applications is scarce[14] which is expectable given the early stage the development of the field is in. However, early insight into consumer acceptance is important, as it can inform the further development of the technology, its positioning in the consumer domain and the communication surrounding it. This study is an early attempt to get to grips with consumer understanding of personalised nutrition.

Research on consumer acceptance of future applications is complicated by the fact that consumers lack an adequate frame of reference and tend to think about future situations in abstract, less elaborate terms. Building on insights from information acceleration (Urban et al., 1996) and construal level theory (Trope & Liberman, 2000), this study used systematically varied filmed scenarios to experimentally manipulate five key perceptions of personalised nutrition as important determinants of consumer acceptance: framing, agreement among experts, which stakeholder group benefits, ease of use, and freedom of choice (Ronteltap, van Trijp, & Renes, 2007). In line with the literature on consumer acceptance of innovations in the food domain (Ronteltap, van Trijp, Renes et al., 2007) the effects of these perceptions on consumer acceptance were hypothesised to be mediated by an identified set of four psychological mechanisms: cost-benefit assessment, perceived risk and uncertainty, perceived behavioural control and subjective norm.

Overall, our results provide strong support for the framework developed by Ronteltap, van Trijp, Renes and Frewer (2007). Cost-benefit assessment appeared to be the most important construct in this process, followed by perceptions of subjective norm. To consumers, nutrigenomics applications will only be acceptable if they see a true added value either for themselves or for the advancement of nutritional sciences. This finding deserves particular attention as consumers can be suspicious towards commercial interests of the food industry (van Trijp & Ronteltap, 2007). Furthermore, the relative importance of subjective norm indicates that personalised nutrition is most likely to be accepted if consumers feel supported by their direct environment to engage in using these applications.

For the more specific consumer perceptions of personalised nutrition, we found that agreement among expert stakeholders, benefits for consumers or scientists, ease of

[14] Please note that there have been some commercial pieces of research into consumer responses to nutrigenomics and personalised nutrition from the US, conducted by Institute for the Future (Cain & Schmid, 2003; Massoud, Ragozin, Schmid, & Spalding, 2001; Oliver, 2005) and International Food Information Council (IFIC; see: http://www.ific.org/foodinsight/2006/jf/genesfi106.cfm and http://www.ific.org/foodinsight/2003/nd/nutritionfi603.cfm (together with the commercial agency Cogent Research).

implementation, and freedom of choice contributed positively to consumer acceptance of personalised nutrition. Of these four perceptions, freedom of choice was by far the most important driver of acceptance. This is in line with previous research suggesting consumer concerns about the misuse of genetic information (Chadwick, 2004). Strong support was found for the hypothesised routes through which consumer perceptions affect acceptance. Additionally, many of the effects of consumer perceptions on acceptance were mediated by considerations of costs and benefits. This illustrates once again the importance of nutrigenomics applications to provide clear benefits to the consumer both in the short-term (direct advantages to the consumer) or in the longer-term from nutrigenomics supporting further scientific progress in the field of diet and health.

This study identified a number of issues to be taken into account in the further development of nutrigenomics and its spin-offs. Throughout the entire process of development, it is important that expert stakeholders, e.g. nutritional scientists, communicate unequivocally about what can realistically be expected from nutrigenomics. Actual spin-off products, e.g. personalised advice or food products, must provide a clearly recognisable advantage to the consumer, and should be easy to implement into daily routine. Note, however, that a recent study shows that agreement among experts and easy implementation are considered unlikely by experts (Ronteltap et al., 2008). Of utmost importance, consumers need to be reassured that making the genetic profile available or using personalised nutrition are options free at their own choice. A supportive communication strategy should be developed to familiarise consumers and their direct environments with personalised nutrition.

Our exploratory consumer segmentation, although not conclusive, showed that consumers differ both in how they value alternative scenarios of personalised nutrition and in the key psychological processes that guide their acceptance. Further research is needed to elaborate on these differences, particularly to understand why ease of use and freedom of choice fulfil such different roles for different groups of people.

Some limitations of the current study need also be addressed. First, the study was conducted in the Netherlands and hence may require further cross-national and cross-cultural validation. Also, the sample of the main study deviates slightly from the Dutch population statistics with an overrepresentation of age group 40-64 yr old and a slight underrepresentation of lower educated respondents and single person households. Such deviations are not uncommon, but might impact on the generalisation of the research findings to the general population. Further, as indicated by one of the reviewers, consumer response to personalised nutritional advice might differ depending on the respondent's attitudes towards diet and nutrition as well as current dietary habits. Exploring these differences might be an interesting venue for future research.

Second, although the pilot study generally supported the successful operationalisation of the filmed consumer perceptions, the manipulation of framing was less convincing. From the current data it is not clear whether the framing manipulation was unsuccessful, or whether acceptance of personalised nutrition is indeed insensitive to message framing (enhancement of quality of life vs. disease risk). Future research needs to clarify this. Finally, due to time and effort constraints, all consumers evaluated a fractional factorial design of 8 out of 48 possible profiles. Although the holdout samples varied, the set of calibration profiles was identical for all respondents, which may have affected the results. Also, fractional factorial designs allow for the examination of main effects only, and not interaction effects between the consumer perceptions. Follow-up research might want to focus on these possible interactions effects in more detail.

All in all, this research is one of the first systematic studies into consumer acceptance of nutrigenomics spin-offs. In terms of marketing potential of nutrigenomics, it showed that freedom of choice, clear consumer benefits at reasonable cost and peer support will be key determinants of consumer acceptance. For the successful development of nutrigenomics and its applications, it is important to take these considerations into account at an early stage.

Appendix A

Film scene: message framing

Many years of nutrition research have taught us a great deal about nutrition and health. This knowledge has, among other things, contributed to our ever increasing life expectancies.
Positive: Therefore, we continue to live longer. Nutrigenomics can enable us to enjoy our extended lives more, to live in good health as long as possible.
Negative: Therefore, we continue to grow older, and the last years of our lives we often live in poor health. Nutrigenomics can enable us to delay diseases, so we can shorten the time we live with deprivations.

Film scene: agreement

The last couple of years, the use of nutrigenomics has increased hand over fist; growing numbers of people have had their genes profiled and eat according to a personalised dietary advice. This development will be discussed by two experts in the field of nutrition and health: Mrs A, who is a family doctor and dietary advisor, and Mr B, who is a professor in health sciences.
Mrs A: *"I am convinced that these diets can contribute to a healthier country. In practice, I experience people feeling better using them; I really see less patients. Of course, a lot of scientific research needs to be done to underpin everything, but based on what we know now I think we should stimulate the use of personalised nutrition."*
Consensus: Mr B: *"I totally agree with her. Indeed, not everything has crystallised out yet, but we definitely have a good starting point, and so I think it is wise to continue this way."*
Dissensus: Mr B: *"I totally disagree with her. We are only at the base of scientific research, current hypotheses are not well supported yet. Based on the little information we have now, I don't think we should stimulate the use of personalised nutrition."*

Film scene: which group benefits

Understanding how our genes influence the way we digest our food is very important, as it leads to understanding the relation between nutrition, health, and disease.
Consumer: What has become clear lately, is that nutrigenomics delivers many benefits to the consumer. By choosing food products fine-tuned to their genetic profiles, people can prevent certain diseases and gain a large health benefit.
Science: What has become clear lately, is that nutrigenomics delivers many benefits to scientists. Because they have a better understanding of how nutrition and genes interact, they can boost research in this genetic field and make a leap forward in science.

Industry: What has become clear lately, is that nutrigenomics delivers many benefits to the food industry. By applying the latest insights from nutrigenomics, they can develop new product lines to sell more products.

Film scene: ease of use

What personalised nutrition entails concretely, is that you visit one of the research centres once. There, they will draw up dietary advice solely for you, because it is fine-tuned to your genes. Such a diet can help you stay healthy longer, or even prevent diseases.

Easy: Following the diet is easy. You can continue eating the foods you were used to, and additionally everybody will receive a unique supplement to be taken daily during meals. This supplement contains exactly those substances you need in the right doses. This means, that all members of a family will be able to eat the same meal.

Complex: Following the diet is not easy. The dietary habits you were used to will have to change. You will have to eat a bit more of one product and a bit less of another. You will also need to use new products that are designed for your genes. This means, that all members of a family will have to eat different meals.

Film scene: freedom of choice

National Centre for Gene Research, district South.

Freedom: Since a couple of months, the government advices to have your genes profiled, because of the importance for public health. In this district, people can pay a visit starting today. In an interview, a representative of the Centre is asked what he expects today:

"I have to tell you, it is very difficult to estimate. This morning was busy for a while, followed by a more quite period. From centres in other districts that have preceded us, we learned that the number of people paying a visit at the first day is highly variable. But we are prepared for everything; our whole team is standby to draw tubes of blood quickly when it starts getting busy again."

Coercion: Since a couple of months, the government obliges people to have their genes profiled, because of the importance for public health. In this district, the blood drawing period started today. In an interview, a representative of the Centre is being asked what he expects today:

"I have to tell you, it is very difficult to estimate. This morning was busy for a while, followed by a more quite period. From centres in other districts that have preceded us, we learned that the number of people paying a visit at the first day is highly variable. But as it is obligatory, we are dealing with a large number of people, so we have to be prepared for everything. Our whole team is standby to draw tubes of blood quickly when it starts getting busy again."

6

MAKING NUTRIGENOMICS WORK

Integrating expert stakeholder opinions and consumer preferences

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Introduction

Until the 1950s, science, technology, and innovation were predominantly considered as linear processes by academics and policy-makers (Leeuwis, 2004; Smits & Kuhlmann, 2004; Vandeberg, Boon, & Moors, 2006). That is, science invents, applied research defines the resulting innovations, companies implement and consumers purchase. This perspective is also called 'the technology push'. Examples of innovation developments this linear model helped to explain can be found in transport (from horse carriages to cars), factory production (from mill factories to mass production), water supply (from pump to piped water), and agriculture (from manpower to tractor). More recent experience has led to the recognition that the linear model also has its limitations, most clearly exemplified by biotechnology and genetic modification (GM) in the 1990s. Some users were very reluctant to adopt innovations resulting from these technologies, such as GM foods, which amongst other things resulted in considerable controversy about their use. Thus, the linear model is inadequate in complex cases, which possess characteristics that engender greatest concern among consumers including whether new technologies are perceived to be involuntary, unobservable, out of control by the consumer and may have unknown, delayed and potentially fatal health effects (Slovic, 1987). Another example of such technology is nuclear energy, about which large-scale societal discussions set-up by governments ran into deadlock. For example, several stakeholders accused the Dutch government of giving society the false impression they had a say in policy, while in reality decisions had already been taken (van Tulder, Kaptein, van Mil, & Schilpzand, 2004). This led to the growing number of nuclear plants coming to a halt, and today, only one is still operational in the Netherlands. The currently prevailing view of innovation development is one of interaction between scientific, social and economic processes (Leeuwis, 2004; Smits & Kuhlmann, 2004). This means the upfront involvement of stakeholders is considered crucial for success in innovation development. Stakeholders are those with a vested interest in a particular product, service or technology, good or bad, and include those who design and implement (experts) and those who are lay-users. For long-term adoption, it is important that all stakeholders participate in designing or adapting the innovation to their own purposes (Green & Kreuter, 2005).

A recent technological development in the area of life sciences is nutrigenomics: the study of genetic material to understand how metabolic processes in the living cell respond to nutritional cues in terms of health. Nutrigenomics resembles biotechnology in that it centres around genes, making public opinion susceptible to the same polarisation in opinion. Different stakeholder groups may have different stakes and opinions on the desirability of such development. In modern society, increasingly a diversity of stakeholders express their stake, but not necessarily their underlying motives, in communication to the end-user (the consumer), and thereby affect the uptake (adoption and diffusion) of any new technology. To ensure coherent communication of the pros and cons of a new technology, it is considered increasingly important that all stakeholder views are taken into account and aligned before the new technology enters the market. In the case of nutrigenomics, similar to many other technologies, several expert stakeholder groups can be distinguished: academics, policymakers, food industry, non-governmental interest groups, health professionals, and media (Ronteltap, van Trijp, & Renes, 2007).

Dialogue can be a powerful instrument to strengthen social embedment by actively involving stakeholders in innovation development, making them co-responsible for the result. It is a means to become familiar with other parties' points of view, exchange thoughts and ideas, build mutual trust, and discuss potential co-operation (van Tulder et al., 2004). This implies collective decision making as to the desired direction of new technologies and innovation. Collaborative tools are indispensable to enable sharing of information and expertise for efficient and effective communication in (stakeholder) dialogues. A novel type of information and communication tools, called Group Support Systems (GSS), provide structured support for stakeholder interaction (Bragge, Merisalo-Rantanen, Nurmi, & Tanner, 2007). They facilitate anonymous and parallel brainstorming, discussion, organising, priority setting, decision making, and automated reporting, and are judged to be more productive and effective than traditional meetings by participants (Bragge et al., 2007). In contrast to other methods to collect expert opinions, e.g. individual interviews, a group discussion stimulates interaction between the different stakeholders. Interaction provides synergy because every opinion, suggestion or idea is tested and accentuated real-time by the other participants, leading to richer data. One specific type of GSS meeting environment is the Group Decision Room (GDR). The GDR is a room with an electronic meeting support system which can be used for a participative approach to complex tasks. In a GDR, each individual working space is provided with a computer with which the participants can collaborate, supported by the electronic meeting system (Rouwette, Vennix, & Thijssen, 2000). The elements of the meeting's agenda can be programmed into the system, structuring the discussion and keeping it focused on the goals of the meeting.

In this paper, we aim to give an impetus to a stakeholder dialogue on nutrigenomics using a GDR with representatives of all expert stakeholder groups. Besides initiating a dialogue among expert stakeholders, this study intends to incorporate consumer views as well. As mentioned earlier, stakeholders include all those with an interest in the topic, both expert and lay. Previous research into public acceptance of nutrigenomics science and innovations arising from it such as personalised dietary advice has argued that the role of consumers is essential (Ronteltap, van Trijp, & Renes, 2007; Ronteltap, van Trijp, Renes et al., 2007; Schmidt, White, Reinhardt Kapsak, Conway, & Bailey, 2007). We seek to identify expectations held by the various stakeholders about the future of nutrigenomics to gain more insight into issues of agreement and disagreement among experts, and between experts and consumers. Thus, our research is centred around the following research questions:

1. What is the communal expert view on the future of nutrigenomics?
2. To what extent do expert expectations concur with consumer preferences?
3. Which action points should have highest priority on a joint nutrigenomics agenda?

The value of this approach is (1) physically bringing together the stakeholder group representatives to exchange and discuss views (see Ronteltap, van Trijp, & Renes, 2007) to build mutual understanding and consensus; and (2) rather than leaving this discussion within the domain of expert groups, it facilitates external validation (e.g. van Kleef, van Trijp, Luning, & Jongen, 2002) of expert views by confronting them with consumer opinions obtained from recent consumer acceptance data on nutrigenomics (Ronteltap et al., in press). To our knowledge this is the first study taking this approach in the context of an innovative technology, such as nutrigenomics.

Approaches used

Data were collected from two GDR[15] sessions led by a technical facilitator and a discussion leader. The GDR consists of networked PCs in a U-shaped arrangement and a screen visible to all participants, to enable participants to provide individual input before sharing it. This set-up allowed for discussion of similarities and differences among stakeholder opinions and their underlying motivations. We used stimulus material developed for previous research among consumers (Ronteltap et al., in press) as a starting point of discussion. We then contrasted the expert consensus view with those expressed by consumers, again focusing on similarities, differences, and underlying motivations.

In GSS, the discussion is modelled with standard components, or tools, which can be selected and combined according to the specific needs of a study. Each tool automatically produces transcripts containing all written communication and quantitative results from the session (Bragge et al., 2007). From the GDR toolbox, we used the voting and categoriser tool to structure the discussion. The voting tool allows the researcher to present participants with stimulus material. Immediately after voting, results appear centrally and anonymously. The categoriser tool is specifically suitable for situations without pre-defined propositions where open brainstorming by the participants is required. Participants individually enter statements into the system that appear centrally without reference to the author, after which all statements are fine-tuned in a plenary discussion.

Two sets of stimulus material, obtained from previous research, were used in the GDR sessions. First, experts were confronted with a systematically varied set of nine scenarios for which consumer preferences (as a measure of acceptance) were known from previous

[15] Located at LEI (The Agricultural Economics Research Institute) at the Hague, The Netherlands.

consumer research (Ronteltap et al., in press). These scenarios comprise a fractional factorial design (see data analysis section) of five factors: (1) how communication to the consumer is framed (positively vs. negatively), (2) the extent to which expert stakeholders agree with each other about nutrigenomics (agree vs. disagree), (3) the group that primarily benefits from nutrigenomics (industry, science or the consumer), (4) the ease with which nutrigenomics-based products and services can be implemented in daily life (easy vs. difficult), and (5) whether or not the nutrigenomics development allows freedom of choice for the consumer (freedom vs. coercion). The nine scenarios are reproduced in key words in Table 6.1, but were explained in more detail to the GDR participants during the session.

Table 6.1. Scenario stimuli (orthogonal set: A-H, additional scenario: I)

Factors:
1) *How communication to the consumer is framed*
2) *The extent to which expert stakeholders agree with each other about nutrigenomics*
3) *The group that primarily benefits from nutrigenomics*
4) *The ease with which nutrigenomics-based products and services can be implemented in daily life*
5) *Whether the nutrigenomics development allows freedom of choice for the consumer*

A	1)	positive	**B**	1)	negative	**C**	1)	negative
	2)	agreement		2)	disagreement		2)	agreement
	3)	science		3)	science		3)	science
	4)	easy		4)	complex		4)	easy
	5)	freedom		5)	coercion		5)	coercion
D	1)	positive	**E**	1)	positive	**F**	1)	negative
	2)	agreement		2)	disagreement		2)	agreement
	3)	industry		3)	consumer		3)	consumer
	4)	complex		4)	easy		4)	complex
	5)	coercion		5)	coercion		5)	freedom
G	1)	positive	**H**	1)	negative	**I**	1)	negative
	2)	disagreement		2)	disagreement		2)	disagreement
	3)	science		3)	industry		3)	industry
	4)	complex		4)	easy		4)	complex
	5)	freedom		5)	freedom		5)	coercion

Eight of the five-factor scenarios (A – H) constitute an orthogonal design, complemented with the scenario that produced the lowest level of consumer acceptance in the consumer study (scenario I).

A second set of stimuli consisted of a list of 12 more detailed success and failure factors, relating to the potential benefits of nutrigenomics, marketing issues, communication and interaction with society, ethical and legal aspects, and scientific research. This list (see Table 6.4) was obtained from previous individual interviews with experts in the nutrigenomics field (Ronteltap, van Trijp, & Renes, 2007), and was discussed within the GDR sessions (see building block 2 below).

The GDR sessions in this study were composed of the following building blocks:

1. The experts were presented with a set of nine pre-defined scenarios for the future of nutrigenomics and were asked to rank-order these individually based on their perceived probability of occurrence. The ranking results were aggregated and displayed at the central screen for discussion of the underlying motivations (voting tool).
2. Participants were then confronted with a pre-defined set of 12 success and failure factors obtained from previous research (Ronteltap, van Trijp, & Renes, 2007). These factors were to be rated individually on the extent to which they were believed to be inhibiting or stimulating the future development of nutrigenomics. For this purpose, a 10-point semantic differential scale was used with end poles labelled as 'strongly inhibiting' (-5) to 'strongly stimulating' (+5). The aggregated rating scores were then displayed and discussed collectively to uncover underlying drivers of the rating results (voting tool).
3. Experts were again asked to rank-order the set of nine scenarios, but then based on what they expected consumers to favour. A comparison between expert probability ratings, expert expectations of consumer preferences, and actual consumer preferences was tabulated and displayed at the central screen (voting tool).
4. During a short break, the experts' ratings on probability of occurrence of the nine scenarios were mapped onto consumers' preference for these scenarios in a two-dimensional space. Participants were then confronted with the map of consumer vs. expert judgments to discuss similarities and differences (categoriser tool).
5. Participants were asked to individually enter key action points that they felt need to be addressed in the near future by the nutrigenomics field (i.e. all stakeholders). All action points were collated on central screen, and then discussed and agreed upon in a plenary discussion until a concise list of action points remained (categoriser tool).
6. Finally, the action points from this list were rated by the experts individually on level of priority on a 10-point scale, higher scores representing higher priority (voting tool).

To ensure adequate representation of all major stakeholder groups (i.e. academics, policy-makers, food industry, non-governmental interest groups, health professionals, and media) in the Dutch debate on nutrigenomics, multiple representatives from each stakeholder group were approached. From the 30 selected stakeholders[16], 22 agreed to participate in a GDR session. Due to busy schedules and illness, 10 of these representatives had to cancel shortly before their session, so eventually 12 stakeholders, representing all main groups, participated (listed in Table 6.2). The participants were assigned to one of the sessions based on availability. Data were collected in March 2007.

[16] In a previous study, we individually interviewed representatives of 29 Dutch stakeholder groups in the field of nutrigenomics based on the network of the Dutch National Genomics Initiative (a governmentally funded research investment organisation) (Ronteltap, van Trijp, & Renes, 2007). These 29 experts were approached for this study, too. If they had left the organisation they worked for previously, replacement within the organisation was sought.

Our analysis is based on the quantitative results generated in the various GDR tools, further enriched with qualitative information obtained from the sessions and represented in session notes and observations. All voting results are examined in terms of means (as a measure of relative importance) and dispersion (as a measure of (dis)agreement among participants). The categoriser results are subjected to qualitative content analysis.

Table 6.2. Participants in the GDR sessions

Session 1 (N=5)	
1	Academia – Nutrigenomics
2	Government – Health Council
3	Government – Institute for Technology Assessment
4	Industry – Strategic Communication
5	NGOs – Nutrition Centre
Session 2 (N=7)	
6	Academia – Bio-ethics
7	Government – Centre for society and genomics
8	Industry – Multinational food production
9	NGOs – Future image of technology
10	NGOs – Patients
11	Health care providers – Allergology
12	Media – Biotechnology journalism

The nine systematically varied scenarios that experts evaluated on the future of nutrigenomics to deliver personalised nutrition constitute a carefully chosen subset (fraction) from the total set of 3 x 2 x 2 x 2 x 2= 48 possible scenarios that could be developed from the five factors (the full factorial design). Together, they form a so-called fractional factorial design that can be used for a conjoint analysis on its rating. A fractional factorial design is that particular set of scenarios (out of all possible scenarios) that would still allow an unconfounded test of the main effects for all five factors that underlie the design (Box, Hunter, & Hunter, 2005). Using conjoint analysis (Green & Srinivasan, 1978), which is essentially an analysis of variance that can also be expressed as a linear regression analysis model with dummy-coded factors levels (e.g. positive framing vs. negative framing), the unique contribution of each factor level (e.g. positive framing) to a dependent variable (e.g. expert ratings on probability of occurrence) can be estimated. These are called part-worth values in conjoint analysis. The relative range of part-worth values across the levels of a particular factor in the design (e.g. framing) can be interpreted as a measure for relative importance of that factor in explaining the expert ratings. As in this particular study, the fractional factorial design was identical to that used in consumer research (Ronteltap et al., in press) the part-worth values and relative importances of each of the five factors can be directly compared between experts and consumers.

Communal expert view on nutrigenomics future

Table 6.3 shows the expert rank-ordering of the nine scenarios in terms of their perceived likelihood of occurrence. Kendall's coefficient of concordance (W) of 0.53 ($\chi 2$ (8)= 50.91; $p < 0.001$) (Churchill Jr., 1995) shows considerable agreement among experts' expectations on the future of nutrigenomics and personalised dietary advice arising from it. This consensus is further illustrated by the fact that 8 out of 12 participants believed the same scenario (G) was most plausible. The majority expected that nutrigenomics will be communicated in positive terms, primarily to the benefit of scientific progress, but with experts disagreeing about its potential. In consumer terms, they expected that the recommendations from nutrigenomics will be difficult to implement in daily life, and consumers will have full control over their participation in the nutrigenomics development. There was also considerable consensus that scenario E is the least likely path for nutrigenomics to develop. This scenario describes the situation in which communication will be negatively framed, experts disagree about the potential of nutrigenomics, the consumer will be the primary beneficiary of nutrigenomics, there will be coercion to participate in the nutrigenomics development, and it will be easy to implement in daily life.

Table 6.3. Expert ranking of likelihood of occurrence

		Rank										
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Sum**	**STD**
Scenario												
G	positive, disagreement, science, complex, freedom	8	2	1	0	0	1	0	0	0	99	1.5
H	negative, disagreement, industry, easy, freedom	2	2	3	3	1	1	0	0	0	82	1.5
A	positive, agreement, science, easy, freedom	0	2	4	4	1	0	1	0	0	76	1.4
F	negative, agreement, consumer, complex, freedom	1	3	3	2	0	0	0	0	3	69	3.0
B	negative, disagreement, science, complex, coercion	0	0	0	2	5	4	0	1	0	55	1.1
I	negative, disagreement, industry, complex, coercion	1	0	1	1	2	4	1	0	2	53	2.3
D	positive, agreement, industry, complex, coercion	0	3	0	0	1	1	3	3	1	49	2.6
C	negative, agreement, science, easy, coercion	0	0	0	0	2	1	4	3	2	34	1.3
E	positive, disagreement, consumer, easy, coercion	0	0	0	0	0	0	3	5	4	23	0.8

W= .53 (p < .001)

More detailed insight into the underlying structure of experts' probability rankings can be obtained from the relative contributions (so-called part-worth utilities) for all levels of the factors to overall ratings (see Table 6.5, 1st column)[17]. The part-worth values show that stakeholder group representatives were most confident that the future of nutrigenomics will allow personal freedom on the part of the consumer and that it will be primarily science and industry who benefit from the development, more so than the consumer. There was also considerable agreement among participants that nutrigenomics recommendations for

[17] Note that to ensure anonymity, individual rank-order data are not available from the GDR session. Hence, the part-worth values were estimated from the aggregated rank-order sum data.

personalised diets will require adjustments to current habits on food choice and consumption as it will not be easy to implement them in daily life. Agreement among experts and whether communication would be in positive or negative terms were much less determining factors in experts' visions on how nutrigenomics will develop in the future.

From the 12 critical success and failure factors that might stimulate or inhibit the further development of nutrigenomics (Table 6.4), there was consensus among stakeholder group representatives about the top three stimulating factors. Nutrigenomics development is likely to be more successful if industry sees potential, clear health benefits for the consumer are arising from the nutrigenomics development and genomics research is heavily invested in. Factors that might inhibit the further development of nutrigenomics include the occurrence of a scandal related to nutrigenomics and, interestingly, if all stakeholder groups in society would participate in the public debate on nutrigenomics. However, the relatively high standard deviations indicate that there were lower levels of consensus on these inhibiting factors. Some participants believed that broad societal representation in a public debate might lead to a focus on fear rather than on opportunity. Patient organisations may be afraid that their members turn out to be uninsurable, for example. Others' counter-argument was that missing out important groups in a societal dialogue might lead to less support for nutrigenomics, much like the biotechnology deadlock, whilst involving all groups would ensure all interests to be served. Concerning the occurrence of a nutrigenomics scandal, some stakeholders argued that any attention to a topic can contribute positively to the topic's development, even if this attention is negative.

Table 6.4. Rating of influence of success and failure factors on nutrigenomics development

	mean	STD
Industry sees potential in spin-off products/services	3.7	1.2
The health benefit for the consumer is clear	3.6	1.7
Genomics research is invested in heavily	3.0	1.6
A large predictive ability of the genome for health	2.8	2.1
Growing consumer interest in nutrition and health	2.4	1.4
Large gain in public health for the government	1.9	2.6
The source of nutrigenomics information is reliable	1.8	1.5
Food is increasingly being medicalised	1.8	1.8
Occurrence of a scandal surrounding nutrigenomics	-1.3	3.3
Targeted nutrigenomics education to the public	1.1	1.4
Tight regulation of claims on products/ services	0.8	2.6
All groups in society participate in public debate	-0.4	2.3

Expert expectations vs. consumer views

Similarity between expert expectations (probability of occurrence and anticipated consumer preference) and true consumer preferences was assessed from direct comparison of the rank-orderings of the nine scenarios (using Spearman's rank correlation coefficient, r_s) and the underlying part-worth values. Experts were able to anticipate consumer preferences for the further development of nutrigenomics (r_s= 0.97; $p < 0.01$). However, in terms of what experts expect to happen in the future there was much less correspondence with what consumers prefer (r_s= 0.57; ns).

The three sets of importances and part-worth values (see Table 6.5) enable comparison of the structure underlying the various rankings. Experts' assessments of consumer preferences correspond fairly well with actual consumer preferences in terms of part-worth values on the factor levels. For example, experts correctly anticipated that freedom of choice for participation in the nutrigenomics development is a crucial factor in consumer preference and that how nutrigenomics is communicated is relatively unimportant to consumers. However, they overestimated the importance of who benefits from the nutrigenomics development. Experts assume that consumers will only accept the development if it is for the benefit of consumers, whereas consumers will also accept it if science benefits. Also, consumers pay more attention to the ease of implementation of nutrigenomics into their daily lives than experts anticipated. However, these differences have limited impact on the experts' empathy towards true consumer preferences for nutrigenomics development as evidenced by the high rank correlation (r_s= 0.97; $p < 0.01$).

Table 6.5. Relative importances and part worth utilities of factors for expert likelihood judgments, and anticipated and actual consumer preference

Factor level	Expert probability		Anticipated consumer preference		Actual consumer preference	
	Importance	Utility	Importance	Utility	Importance	Utility[a]
Framing	2.06		4.84		1.51	
positive		0.88		1.88		0.01
negative		-0.88		-1.88		-0.01
Agreement	9.12		7.42		18.65	
high		-3.88		2.88		0.16
low		3.88		-2.88		-0.16
Who benefits	23.53		31.61		16.68	
consumer		-13.17		15.67		0.09
science		6.83		-6.83		0.10
industry		6.33		-8.83		-0.19
Ease of use	16.76		2.90		16.08	
high		-7.13		1.13		0.14
low		7.13		-1.13		-0.14
Freedom of choice	48.53		53.23		47.07	
high		20.63		20.63		0.41
low		-20.63		-20.63		-0.41

[a] *As the part worth utilities of actual consumer preference are based on ratings on a different answering scale, only patterns (rather than numerical values) can be compared directly to the other sets of utilities.*

r_s (Anticipated consumer preference – Actual consumer preference)= .97 ($p<.01$)

r_s (Expert probability – Actual consumer preference)= .57 (ns)

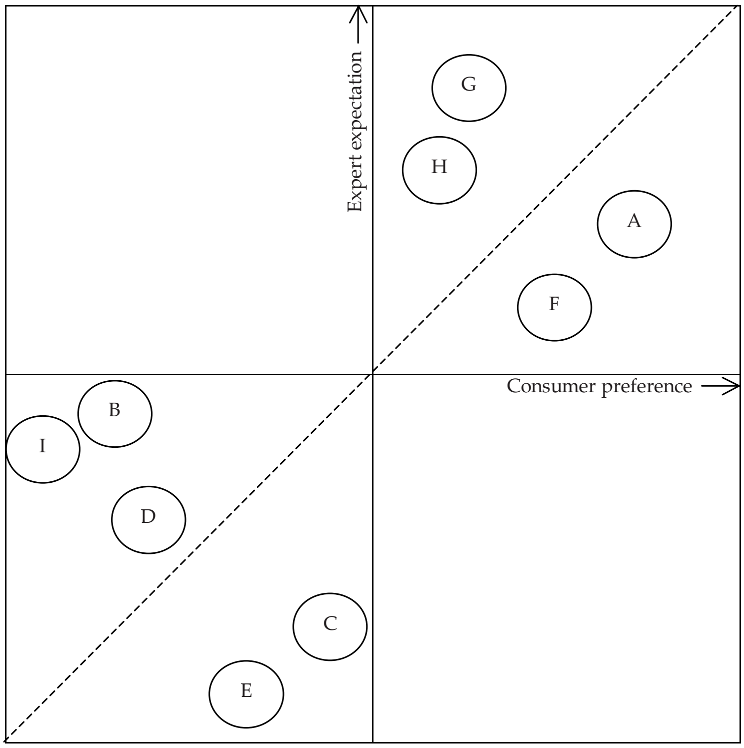

Figure 6.1. Confrontation map between expert expectation and consumer preference

However, despite high expert empathy for consumer preferences, what experts expect to happen in the development of nutrigenomics deviates considerably from what (they know) consumers desire (shown by both Table 6.5, 1st vs. 3rd column, and Figure 6.1). In Figure 6.1, the nine scenarios are mapped onto a space defined by two dimensions: true consumer preference and expert expectations on how nutrigenomics will actually develop. As the figure shows, the scenario ratings cluster in the upper right and bottom left quadrant, suggesting substantial correlation. Closer examination, however, reveals that the factor 'freedom of choice' is largely responsible for this distribution (consumers are free to choose in scenarios A, F, G, and H; and are coerced in scenarios B, C, D, E, and I). This finding is supported by the relative importances in both evaluation sets (Table 6.5), which show a dominance of this factor over the others. Beyond this effect of freedom of choice, it becomes clear that, generally, consumers prefer nutrigenomics to be easy to implement in daily life and experts to agree with each other about nutrigenomics. Experts, on the other hand, expect that it will be complex to use nutrigenomics and that there will not be agreement among them. In the discussion, participants argued that lack of consensus is an inevitable part of scientific development, but acknowledged that it might cause confusion among consumers. Furthermore, experts expect science and industry to benefit from the development, whereas for consumers the development would be more acceptable if consumers and science would benefit. The discussion refined experts' point of view in that they do believe that consumers can benefit from nutrigenomics at some point in the future, but that they do not expect that to happen in the short term. Communication framing was distributed without a clear pattern, which was sustained by its low relative importance in both evaluation sets. In the discussion, it was suggested that this factor might gain importance by the time of market entry of spin-off products, i.e. when consumers are to make a purchase decision.

In conclusion, experts seem to be well aware of what consumers would prefer in terms of how nutrigenomics should unfold, but at the same time do not expect that this is the route that nutrigenomics development will take. Although they expect that in terms of voluntary participation (i.e. freedom of choice) nutrigenomics development will follow consumer preferences, this is much less the case for easy implementation in consumer life and expert agreement, both preferred by consumers.

Integration of stakeholder views: action points and priority setting

To translate the insights obtained from the GDR sessions into starting points for nutrigenomics development and innovations such as personalised dietary advice arising from it, the final discussion dealt with actions that should be taken by the various stakeholders. The two sessions taken together resulted in 28 action points, freely articulated by the respondents. The 10 most important action points (with an average priority rating[18] $M \geq 7$) are discussed in more detail.

Answering the question which benefits nutrigenomics will actually deliver to society was rated top-priority (M= 8.6). Science and industry were held responsible for this as they are developing the technology and, therefore, the onus of proof lies with them. Also of a high priority was the urge for science, industry and government to be conservative and realistic about nutrigenomics' potential (M= 8.1). One participant illustrated this action point with *"we first need to elucidate the gap between desirability and likelihood to close it."* The next three action points received equal priority ratings of M= 7.8: (1) The establishment of a public authority to inform consumers about the scientific status of nutrigenomics. The government was seen as the responsible stakeholder for this action point, as they already have bodies suitable for this purpose (e.g. the Nutrition Centre). Such an authority should function as an intermediary between science and public, distilling relevant and understandable messages from the complex whole of research results; (2) Start an ongoing discussion with all stakeholders about the development options of nutrigenomics and the desirability of these options. The government should initiate the dialogue, but the other stakeholder groups were held just as responsible for a legitimate course of the dialogue; and (3) An absolute guarantee should be

[18] The average priority ratings should be regarded as indicative numbers.

provided by government and health insurance companies that the decision to use nutrigenomics products and services will lie entirely in consumers' hands. This action point relates back directly to the results of the scenario ranking tasks, which showed the utmost importance of the factor 'freedom of choice'. The next action point (M= 7.6) related to the need for all stakeholders to be specific about which products and services nutrigenomics will deliver and with which health benefits for the consumer, the purpose of which is to create clarity and transparency for society. Regulation of nutrigenomics claims by the government was another priority (M= 7.4). This point is also a call for honesty and clarity, but is explicitly about legislation, in which a strict distinction should be made between 'hard' and 'soft' claims in terms of effectiveness. Furthermore (M= 7.1), attention should be paid to potentially controversial issues (in)directly linked to nutrigenomics, such as animal experiments for the purpose of nutrigenomics research or the use of nano-particles (another new technology) for nutrigenomics-based products. In view of the potentially huge impact of non-governmental organisations who work on these issues on public opinion, these issues should be kept in mind. A more integral governmental policy with respect to health and lifestyle was on the priority list (M= 7.1). Policy should not only focus on nutrition and physical exercise for the prevention of lifestyle-related diseases such as obesity and metabolic syndrome, but also should incorporate all causal factors including genetics. Only then can nutrigenomics have a true added value for public health. Lastly (M= 7.0), all stakeholders should keep the social-cultural meaning of nutrition in mind, as nutrigenomics may well imply an increasingly medicalised perspective. The remaining action points were judged to be less urgent (M< 7.0), and broadly clustered around the themes of communication to the public (e.g. that it should be univocal and factual), research issues (e.g. the importance of continuous investments), and legislation on the management of genetic data.

In summary, many of the action points formulated by the body of stakeholders in this study were related to transparency, honesty, and sense of reality. The government was indicated most frequently as the responsible actor.

Current and future trends

Nutrigenomics is a potentially promising development in food science and technology. However, it is still in its infancy, and there are quite some uncertainties about its further development both from a technological and a societal acceptance point of view. Also, different stakeholder groups hold different views on the desirability of alternative development routes for nutrigenomics. It is important to understand the divergence and overlap in stakeholder views as these will need to be taken into account for the successful introduction of nutrigenomics into society. Stakeholder dialogue is a method specifically focusing on the balanced assessment of all stakeholders' views, both drawbacks and preferences, to ensure broad societal support of new science and technology (Borch & Rasmussen, 2005). This paper applied the methodology of Group Decision Room, a specific research tool to facilitate stakeholder dialogue, to develop a synthesis on the further development of nutrigenomics obtained from a broad spectrum of relevant stakeholder groups' views. By direct interaction and discussion, it was aimed not only at sharing views but also at the development of mutual understanding and consensus development. To our knowledge, this is the first attempt to such a synthesis in the field of nutrigenomics, although the stakeholder dialogue approach has been applied in other diet-health related domains (Astrup, Bovy, Nackenhorst, & Popova, 2006). The present study extends beyond standard stakeholder dialogue in that it included actual consumer preferences to be incorporated in the discussion. Thus it not only allowed discussion between experts and their different stakes, but it also externally validated stakeholder views against actual consumer preferences (see also van Kleef et al., 2002).

The results of the Group Decision Room show that stakeholders are well aware of consumer preferences, but that they do not expect nutrigenomics to develop fully in line with those consumer preferences. Two factors are largely responsible for this finding. Experts do not expect that the consumer-desired consensus between stakeholders on the potential and value of nutrigenomics will materialise, nor that nutrigenomics-based products and services will be easy to implement in daily life as desired by consumers. These insights can serve as valuable input for follow-up dialogue between nutrigenomics stakeholders, as they indicate where the largest discrepancies between expert expectations and consumer wishes originate.

The discrepancies between expert expectations and consumer demands illustrate two important aspects in the adoption of any health-related food or dietary advice. First, as health is a quality that cannot be verified by the consumer, not even after normal consumption of the product or adoption of the dietary advice (a so-called credence quality; (Darby & Karni, 1973)), consumers critically rely on information from relevant experts in their belief formation about healthiness. If such information is unequivocal as in the case where different experts express highly divergent views on the (un)desirability of the nutrigenomics and personalised nutrition development, it will lead to uncertainty on the part of the consumer. This in turn may seriously reduce the credibility of the nutrigenomics development and make it less likely that consumers will adopt the personalised dietary advice arising from nutrigenomics. However, full agreement is not a realistic option as there will always be multiple perspectives on the potential of nutrigenomics and personalised dietary advices arising from it. Rather, from a consumer perspective it would be highly desirable if expert stakeholders could manage to develop a set of evidence-based rules, resulting in shared position statements as to when, for whom and in which situations nutrigenomics may or may not provide clear health benefits to certain groups of consumers. Second, also this study on nutrigenomics and personalised nutrition illustrates the importance of perceived ease of use and usefulness as key drivers of innovation adoption (Ronteltap, van Trijp, Renes et al., 2007). This is a highly consistent finding since the early research on diffusion of innovations by Rogers (Rogers, 1962; 2003) and appears equally applicable to the adoption and diffusion of nutrigenomics and personalised nutrition. It illustrates that consumers in general show limited willingness to compromise on other benefits (such as convenience) when adopting health products or health-related dietary advice. It will be crucially important that the personalised nutritional advice is given in a format that consumers can easily implement in their daily diet, also because eating is often a social event. This will be more easily achieved when the nutritional advice is in terms of main stream food products to be avoided or eaten in larger quantities than in terms of specialised products from which only one of the household members would benefit. A key challenge will be to develop nutrigenomics-based foods that can be implemented in the diet for the total household. That is, foods from which the targeted individual will benefit without compromising on healthiness for the other household members.

To a considerable extent, these consumer concerns are also reflected in the consensus among stakeholder groups on what they see as critical action points to be addressed in the further development of nutrigenomics. They agree that it is crucial for the body of expert stakeholders to be transparent about their views on nutrigenomics, and to provide as much clarity as possible to the public. An important element in this approach is that stakeholders should be explicit about what products and services nutrigenomics will actually deliver, and how each of these can provide health benefits to the consumer. To ensure that these insights can be acted upon, participants acknowledged that continuous dialogue between all stakeholders is required.

Despite its contribution to enhancing stakeholder involvement and commitment, as a first study the approach adopted here is not without its limitations. First, stakeholder dialogues require that professionals with busy schedules invest a considerable amount of time and effort. It proved difficult to bring them together at one place at one particular time. In general (Rouwette et al., 2000), this will have a negative impact on the response rate, as exemplified in this study. Also, in this study the stakeholders were only provided with a small fraction of all possible development directions of nutrigenomics. These were based on prior research among the expert stakeholders and selected to form a fractional factorial design with optimal efficiency. However, a drawback of this approach is that it does not allow an analysis of potential interaction effects between the dominant factors that drive expert expectations and consumer preferences. This might be a fruitful issue for future research. Finally, the present study focused on the Dutch situation where we found relatively limited controversy on the future of nutrigenomics both among experts and between experts and consumers.

In conclusion, this study found considerable consensus and limited controversy in stakeholder views on the future of nutrigenomics. There is an agreed upon set of actions that needs to be worked on by the stakeholders collaboratively, mainly related to transparency, honesty and sense of reality. Stakeholders are well aware of consumer preferences, but do not expect nutrigenomics to develop fully in line with those preferences. We hope that these Dutch results and the methodology chosen may inspire further work in an (inter)- national context on the future of this promising technological development in nutritional science.

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7

Discussion

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Nutrigenomics is a new scientific development in nutritional sciences with great potential for further unravelling the relationships between the diet, health and disease at a very detailed level. Although still at its early stages of development, there is little doubt that the field of nutrigenomics (including proteomics, metabolomics, and transcriptomics) will move nutritional sciences to a next level. Nutrigenomics also holds considerable potential for consumer products in the form of personalised nutritional advice and personalised diets on the basis of an individual's genetic constitution. Despite doubts about the scientific substantiation (Kutz, 2006), the first commercial applications of nutrigenomics have already reached the market in the form of tests to identify individual genotypes (see, for example, www.mycellf.com).

Summary and conclusions

However, relatively little is known about the public acceptance of nutrigenomics-based personalised nutrition. The present thesis took up this challenge in studying the determinants of its public acceptance at this early stage of scientific innovation development. In doing so, this research took a marketing and consumer behaviour approach to genomics-based personalised nutrition. In this light, personalised nutrition is an example of value exchange, where ultimately individual consumers and food companies are involved in an exchange process that is advantageous to both parties involved. As nutrigenomics is an emerging science and its consumer applications through personalised nutrition are in their infancy, stakeholder views are still under construction. Stakeholders are those people or groups with a vested interest in a particular product, service, or technology, including both experts and lay people (i.e. consumers), all with their own specific interests (Green & Kreuter, 2005). Yet stakeholder views are critically important in shaping the future success of nutrigenomics-based personalised nutrition applications. For an integral understanding of the public uptake of personalised nutrition it is important to assess and integrate the viewpoints of the crucial stakeholders involved. This primarily concerns the viewpoints of the consumer and the supplier involved in the value exchange, but also those of other stakeholders involved in the broader field: e.g. scientists, policymakers, and health professionals. This thesis has investigated and integrated those different viewpoints.

Chapter 2 (van Trijp & Ronteltap, 2007), analysed the concept of personalisation in detail. Building mainly on marketing and consumer behaviour literature we conceptualised personalised nutrition as a value exchange originating from the interaction between the company and the individual consumer. As such we took a cost-benefit perspective and specified the costs and benefits of personalising nutrition for both the firm and the consumer side of the interaction. In short, the costs for the company are those related to the resources required to deliver personalised offerings, with potential returns in terms of a price premium they may charge for personalised products and advices, improved customer relationships that may arise from personalisation and ultimately an enhanced brand image. For consumers, the main costs are a potential loss of taste as their favourite foods may not be part of the personalised advice, loss of convenience in meal preparation due to diversity in the family dinner, privacy concerns with respect to making intimate genetic information available to others, and the higher price they would have to pay for personalised solutions. In addition to enhanced personal health, the benefits to consumers may also arise from the simplification of the choice process as well as the value they may derive from co-designing the marketing offering and participating in the interactive process.

Chapter 3 (Ronteltap, van Trijp, Renes et al., 2007) zoomed in on the consumer perspective arguing that genomics-based personalised nutrition is an example of technology-based food innovation. From an integration of the relevant literature within and outside the food domain, a conceptual framework for consumer acceptance of technology-based food innovations was developed and applied to genomics-based personalised nutrition. A distinction was made between 'distal' and 'proximal' determinants of consumer acceptance arguing that distal determinants (characteristics of the innovation, the consumer and the social system) influence consumers' intention to accept an innovation through an identified set of proximal factors. The key proximal determinants identified in the conceptual framework are the perceived cost/benefit considerations, perceptions of risk and uncertainty, social norm and perceived behavioural control.

Three empirical studies explored expert and lay stakeholder views on the critical success and failure factors for the further development of nutrigenomics-based personalised nutrition. *Chapter* 4 (Ronteltap, van Trijp, & Renes, 2007) elaborated on expert stakeholder views on the critical factors for nutrigenomics and personalised nutrition. These views were elicited through 29 semi-structured interviews with Dutch experts in the field, covering a wide range of stakeholders from industry, government, science, health care, NGOs, and media. The results revealed that currently there is limited consensus between expert stakeholders about what nutrigenomics is and is not, the time needed for the field and its applications to develop and the factors that will determine market success or failure.

Building on the conceptual framework (*chapter* 3) and the stakeholder views (*chapter* 4), *chapter* 5 (Ronteltap et al., in press) empirically tested a set of key hypotheses on public acceptance of personalised nutrition within a representative sample of Dutch consumers. The results confirm that public acceptance is enhanced if consumers can make their genetic profiles available free at their own choice, if expert stakeholders communicate univocally about nutrigenomics, if the actual spin-off products provide a clearly recognisable advantage to the consumer and are easy to implement into the consumer's daily routines.

Chapter 6 (Ronteltap et al., 2008) brought together the expert and consumer views on the potential of genomics-based personalised nutrition. Using the methodology of Group

Decision Room, experts were confronted with how their views related to consumer views on personalised nutrition, in an attempt to further detail and reconsider their opinions. The results showed that stakeholders are well aware of consumer preferences, but that they do not expect nutrigenomics to develop fully in line with those preferences. Furthermore, the experts agree that it is crucial for them to be transparent to the public about their views on nutrigenomics.

Overall, this thesis has developed new knowledge on (expected) public uptake of genomics-based personalised nutrition and has done so from a multitude of sources. The results suggest that if consumer needs and concerns (e.g. that it is entirely up to consumers whether or not their genetic information is disclosed) are addressed, there seems to be a basis for consumer acceptance of personalised nutrition. However, successful innovation diffusion depends on both the 'demand' and the 'supply' side. In other words, public acceptance of personalised nutrition will hinge on industry seeing sufficient commercial potential in this new development as it is the (food) companies that would have to translate scientific insights into a marketable offering for consumers. From a marketing point of view, personalised nutrition can be conceived of as a focus on increasingly small market segments – ultimately segments of one. In the following section of this chapter, this supply perspective will be addressed in more detail, taking segmentation theory as a starting point.

Marketing potential of personalised nutrition

From a marketing point of view, personalised gene-based nutrition implies that food companies would focus on smaller and smaller consumer segments that are homogeneous in terms of genetic profiles and associated nutritional needs (e.g. Jiang, 2000). To be justifiable as a strategic marketing tool, any segmentation needs to conform to a set of specific criteria: (1) measurability, (2) substantiality, (3) accessibility, (4) responsiveness, and (5) actionability (Kotler & Keller, 2006). In this section we assess the feasibility of personalised gene-based nutrition in terms of these criteria. Segments need to be *measurable* to the extent that individual consumers can accurately and consistently be assigned to segments at justifiable cost. In the case of genetics-based segmentation, this would mean that it should be relatively easy to accurately identify which consumers belong to which genetic segment. Also, segments should be *substantive*, in the sense that the segments identified should be large enough to justify separate marketing programs. Segments should be *accessible*, in the sense that targeted marketing programs could be developed that effectively reach the segment of consumers. Segments should be *responsive*, in the sense that different segments respond differently to the differentiated marketing mixes, as otherwise it would not be profitable to develop these separate marketing programs. Finally, the segments should be *actionable*, in the sense that it is both possible and advantageous to target different segments with different marketing programs. Much of the marketing potential of personalised nutrition will depend on further and as yet unknown scientific progress in the areas of nutrigenetics and nutrigenomics. However, the five criteria for effective segmentation provide a useful tool for reflecting on the marketing potential of personalised nutrition.

In terms of *measurability*, genetics-based personalised nutrition has the advantage that genotype is a segmentation variable that is stable over time. However, the measures are not easily obtained, because of consumer resistance to divulging personal genetic information to third parties, particularly when these are not in the public health domain. Uncertainties exist about how this information will be used now and in the future. For food companies, it is unclear how they can obtain this information with sufficient accuracy and in large enough quantity. In terms of *substantiveness* of the segments, the key question is whether homogenous consumer groups of sufficient size can be identified to justify targeted marketing. In other words, if these are very small groups of consumers it will not be feasible for the mainstream food industry to develop targeted marketing programs, although it may be a relevant niche market with marketing opportunity for entrepreneurial small and medium-sized companies. However, such small segments are probably catered for more efficiently and effectively through the medical segment than through the commercial segment of food companies. In terms of *accessibility*, given that genetic constitution is highly idiosyncratic and not overtly visible, it will be necessary for food companies to reach the segment members through an individualised approach. Consumer reluctance to share this sensitive genetic information directly with commercial food companies complicates such one-to-one marketing interactions with the individual consumer.

The greatest opportunity for marketing personalised nutrition – assuming that once consumers experience the health benefits of personalised nutrition they are likely to actively seek the personalised foods that fit their specific preferences – is *responsiveness* to personalised offerings. However, most of the health benefits are long-term and not easily recognisable by the consumer. Hence it is crucial for personalised nutrition to have demonstrable short-term effectiveness: for example, inducing a change in consumer-relevant biomarkers (such as lowering cholesterol level), or an improved feeling of wellbeing. *Actionability* touches on the distinction between personalisation and mass customisation. There is great potential for giving personalised advice to consumers about which existing products to choose or to avoid. However, the situation becomes much more complex when the challenge is to develop and market personalised food products. This would require customising product offerings to match smaller and smaller segments of consumers, which in turn requires substantial adjustments to the existing food supply chains that are currently based on large-scale production. One possibility would be to develop specialised foods for particular genotype segments; whether this is feasible depends largely on the willingness of this segment to pay a premium price that will cover the extra costs involved in production, distribution, and marketing. Another option would be to add specific nutrients and ingredients to products in the very last step in the production chain: rather like a coffee-vending machine, which allows the consumer to add certain ingredients to the basic product in-store to make it fit with his / her personal nutritional needs. However, this would bring the application of personalised nutrition very close to that of supplements and medicine, and a key challenge would be to meaningfully differentiate the personalised food option from supplements and medicine. Further complicating the marketing of personalised nutrition are the regulations regarding nutrition and health claims (note that in European Union, such regulations have recently come into force). It is expected that genetics-based products will focus either on maintaining health or on reducing risk of disease (or maybe even curing disease). Although claims to this effect are now permitted under the new European Union regulations, they are strictly regulated on the basis of scientific substantiation. The high costs of this scientific substantiation will be borne by a relatively small market segment, because the alternative is that genomics knowledge is publicly available, which substantially reduces the competitive advantage of the institutions that produce knowledge.

Overall, we believe that current developments in nutrigenomics augur well for improving our understanding of the relation between food, health, and disease, and individual differences therein. There is potential for personalised nutrition advice for those segments of consumers willing to make their genetic information available in order to obtain such advice. Some commercial companies such as Sciona are already practicing this particular application of nutrigenomics. Provided that these applications are scientifically sound and consumers are willing to share their genetic information, this may be one route for personalised nutrition to explore. But note that the Sciona business model relies heavily on the marketing of diagnostic kits, not on customised food products. Also, we believe that further advances in the science of nutrigenomics may be helpful in the marketing of food products whose selling point is the absence of certain ingredients and possibly nutrients ("guaranteed free from") as is currently already the case in 'allergen-free' foods. If nutrigenetics provides evidence for sufficiently large consumer segments, this may be an opportunity for the mainstream food industry; otherwise, gene-based personalised nutrition may be a niche market relevant for smaller food companies. However, at present there are too many factors that hinder the commercial application of nutrigenetics-based practices for marketing food products on the basis of their content of specific combinations of ingredients and nutrients. It is unlikely that in the near future the benefits arising from customer loyalty and willingness to pay will outweigh the costs associated with personalised nutrition. The consumer segments are likely to be small and the additional production, distribution, and marketing costs high. For most larger food companies, this will deviate too much from their current business models to justify the effort. There may be potential for small specialist companies, provided that they can get the distribution channel right. However, such applications are more likely to be closer to the medical and supplement businesses than to the food business. In the short term, the added value of nutrigenomics is more likely to emerge from the better insight into the fundamental processes underlying health and disease than in the application of marketing for personalised diets. From consumers' great confidence in and reliance on their family practitioner, we further see that it is this 'communication' channel that has most potential. We therefore believe that genetics-based insights can be best implemented through the existing health systems, with a central role being played by the family practitioner. Our consumer research suggests that commercial applications through fitness and health centers are still a step too far for most consumers.

Much of the existing segmentation and targeting in the food industry is being conducted on the basis of phenotype information rather than genotype information. Market potential should therefore be assessed by examining the added value of genotype segmentation over and above existing phenotype segmentation. For example, it is possible to identify a relevant segment of consumers at risk based on their current blood cholesterol level, on specific lifestyle features (age, lifestyle, job stress, etc.), or based on their genotype information. Blood cholesterol levels are relatively easy to measure and specific psychographic and lifestyle factors are an accessible feature to which communication to the target audience can be tailored. This raises the question of what added value genotype information related to blood cholesterol levels will have for marketing purposes. Clearly, genotype information has the potential for identifying individuals at risk much earlier in their lives, before the phenotype with the high cholesterol level has developed, and this may be important for preventive purposes. However, the crucial factor is the reliability of genotype information for predicting later development of high cholesterol levels, and the extent to which the effect of the genotype can be attenuated by environmental factors like nutrition. Currently, the predictive accuracy seems to be low, especially for diseases like diabetes and obesity that involve multiple genes. Finally, regarding actionability in terms of the development of specific dietary advice and tailored products, the question arises as to whether the additional genotype information would lead to relevant adjustments in the current dietary recommendations about the consumption of macro- and micronutrients.

Despite the above outlined constraints to personalised nutrition becoming a large-scale marketing opportunity, we believe that it has potential to add to public health in the more medically oriented domain. This depends on the advances in the science of nutrigenomics, as complex states of health and disease cannot currently be predicted from genetics. Healthcare professionals like the family practitioner, a highly trusted source of health information, could be important gatekeepers in this process of advising consumers about personalised nutrition.

Limitations and issues for future research

This thesis represents an important first step in systematically bringing together the innovative scientific development of nutrigenomics and its societal stakeholders. As an early contribution to this field, it is not without its limitations. Complementary to the specific limitations already discussed in the empirical chapters, in this section, some overall limitations of the research presented in this thesis are discussed to further nourish the discussion on nutrigenomics and personalised nutrition, and to serve as a source of inspiration for future research. The majority of limitations cluster around the extent and direction to which our findings may change over time and may differ between subgroups in our population, and the extent to which the findings are generalisable to other study populations. This section is concluded with a reflection on our research approach of using filmed stimulus material.

First, based on a review of the literature (*chapter 3*) and expert stakeholder opinions (*chapter 4*), we identified five critical success factors for consumer evaluation of personalised nutrition (*chapter 5*). Although we are confident that these are the most important factors for consumer acceptance, it cannot be ruled out that other determinants may also play a role in individual preference formation processes. Future research seems warranted to further extend and refine the findings reported in this research. Also, it is important to keep in mind that in the present study relative importances of these critical success factors for consumer evaluation were assessed at one moment in time (namely at the early stage of development) in a cross-sectional research design. An important limitation of this study is that it does not provide insight into the dynamics in the importances of these critical factors for consumer acceptance. The importances may change over time, once nutrigenomics-based personalised nutrition becomes more familiar in society. They may also change as a result of consumer and market trends. For example, we found that respondents were very responsive to varying levels of perceived freedom of choice, yet insensitive to message framing. These importances may be reinforced, for example by a persistent trend towards individualisation (Beck & Beck-Gernsheim, 2002), or may shift, for example as a result of demographic changes in society like the growing number of elderly (Commission of the European Communities, 2005). Other factors may come into play as well at a later stage of development, examples including privacy violation related to nutrigenomics, resistance against the 'medicalisation of food' (*chapter 3* of this thesis), misleading claims made by companies offering genetic tests and recommendations (Joost et al., 2007; Kutz, 2006), insufficient regulation of such claims (*chapter 3* of this thesis), or a lack of health care professionals with specialised knowledge in nutrigenomics (Castle & Ries, 2007). Future research should explore how consumer acceptance of nutrigenomics-based personalised nutrition may change over time and as a result of which underlying (psychological) mechanisms. This would require longitudinal research designs rather than the cross-sectional approach taken in this study. Importantly also, the focus of the present consumer study (*chapter 5*) on individual-level acceptance put a constraint on the research design as this allowed assessment of main effects only of the five critical success factors, thereby ignoring the potential interaction between the success factors. A task for future research is to explore how these critical success factors interact in determining consumer acceptance of nutrigenomics-based personalised nutrition.

Second, this thesis confirmed that views on and preferences for nutrigenomics-based personalised nutrition are far from univocal. They differ between (subgroups of) expert stakeholders (*chapter 4*) and also between consumer segments (*chapter 5*). An important contribution of this thesis lies in the identification of consumer segments that differ in the psychological processes on which they base their preferences for personalised nutrition. We were able to describe these segments in terms of a limited number of socio-demographic variables. To our knowledge this is the first publicly available segmentation analysis in this particular area[19]. We showed, for example, that people in the segment with the largest household size, i.e. families with children, attached far more importance to the ease of implementing personalised nutrition in their daily lives compared to the overall sample. However, although our results suggest that different consumer segments can be identified, the segmentation is explorative and primarily descriptive in nature which is a limitation of this study. To be truly effective as a segmentation approach, more work is needed to obtain more insight in the consumer segments in terms of a broader set of psychographics and personality characteristics, for example the extent to which people are concerned about and feel responsibility for their health, how alert they are on health information in the media, their willingness to try new treatments, or the trust they put in their doctors (Cogent Syndicated, 2003). Such analyses will contribute not only by confirming *that* different segments base their preferences on different types of psychological phenomena (e.g. perceived cost/benefit considerations, perceptions of risk and uncertainty, social norms and perceived behavioural control), but also to clarify *why* they do so. This will further enhance the theory-base behind the segmentation approach. Not explicitly included in our segmentation approach, but potentially part of the segmentation basis is individual health status. People who are experienced with diet-related disorders, personally or in their close environments, are more likely to be motivated to take preventive actions than healthy subjects. Food allergies, for example, usually take a long time to be diagnosed correctly by carefully exposing people to suspect food allergens, called food provocations (Ronteltap et al., 2004). If a personalised gene-based approach can deliver exact guidelines on what foods to avoid, allergic patients will experience immediate rather than long-term benefits of personalised nutrition. Such

[19] Note that there are a number of commercial reports on consumer issues related to nutrigenomics and personalised nutrition by the Institute for the Future (Cain & Schmid, 2003; Massoud et al., 2001; Oliver, 2005) and the International Food Information Council in cooperation with Cogent Research (see http://www.ific.org/).

consumer segments are likely to take up the role of Rogers' (2003) innovators who explore the first applications of nutrigenomics science.

With regard to generalisability of our findings, a limitation of the present studies is that they were conducted in the Dutch context only. Nutrigenomics science, however, develops in a multinational context as research groups worldwide are working on it and with global marketing potential. Therefore, it would be worthwhile for future research to examine whether cultural differences between countries result in different criteria consumers and experts use to evaluate personalised nutrition. A striking example in this regard is the difference in public opinion on genetically modified foods between the US and many European countries (Gaskell et al., 1999); where Americans were much more positive. Americans also expressed this positive attitude in commercial consumer research into attitudes toward the broad area of genomics[20]; three-quarters indicated to be favourable toward the idea of using genetic information to provide people with diet-related recommendations. Furthermore, as independence and freedom of choice are values particularly important for consumers in western societies to enhance their perceptions of autonomy (Deci & Ryan, 2000), the weight we found for freedom of choice in *chapter 5* might decrease if studied in more collectivistic cultures. In the framework we developed in *chapter 3*, the distal determinants of innovation acceptance were constituted by characteristics of the innovation, of the consumer, and of the social system. Social system characteristics were kept constant in the remainder of the thesis because of the Dutch demarcation, so a cross-cultural analysis would add substantially to the current knowledge.

In an attempt to bring the emerging nutrigenomics-based personalised nutrition 'to life' for consumers, we presented the respondents in our study with systematically varied scenarios in the form of short documentary-type films. Previous research has shown that using visual rather than verbal stimuli increases the predictive power of concept testing methods for new products (Dahan & Srinivasan, 2000). The use of our innovative visual stimuli is further grounded in construal level theory (Trope & Liberman, 2000) and information acceleration (Urban et al., 1996), aimed to take consumers 'into the future'. By doing so, consumers were provided with a richer and more realistic context against which the future personalised offerings should be evaluated. Respondents indicated that the films not only increased enjoyment of participation in our study, but also gave a realistic and comprehensible impression of what this scientific development could imply for their daily lives. Still, the gap between the here and now of consumers' daily lives and the future in which personalised nutrition may be part of consumers' daily practice, is considerable. Therefore, an avenue for future research would be to investigate how the context in which respondents are asked to express their opinions on future issues can be made even more

[20] See http://www.ific.org/foodinsight/2003/nd/nutritionfi603.cfm

suitable, for example by placing them in a physically futuristic environment. As a disadvantage of using filmed stimulus material should be mentioned that it is rather time-, money-, and labour-intensive. Future studies could more systematically analyse the exact added value of filmed stimuli in comparison to (less costly) pictorial and verbal stimulus material. For a recent review of the role of imagery, rather than verbal encoding, as a persuasion strategy, see Petrovan and Cialdini (2008).

Overall, this thesis has made an important contribution in analysing the marketing and consumer behaviour issues involved in nutrigenomics-based personalised nutrition. To our best knowledge it is the first of its kind. Although we believe that there is potential for marketing of personalised nutrition, in the short run it is more likely to be a niche activity than a main stream marketing offering. This is due to the expected costs involved in personalising food products and nutritional advice to increasingly small consumer segments. A more promising contribution in terms of public health may lie in the more medically oriented domain by targeting consumers already experienced with diet-related diseases, guided by health professionals such as the family doctor.

As the theoretical contribution, underlying our analysis was the newly developed conceptual framework for consumer acceptance of food innovations. In this thesis, the framework was successfully applied to the context of personalised nutrition and is now waiting to be applied to other emerging sciences and new food innovations for further refinement. In conclusion, this research has confirmed and extended existing scientific findings regarding the determinants of public acceptance of innovations while also raising new questions to be solved by future research.

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SUMMARY

Nutrition research has evolved to deliver increasingly specific knowledge on how the human body responds to nutrient exposure by food intake. A recent scientific discipline therein aims at understanding how food components influence health status by affecting gene expression. This discipline is nutrigenomics. Insights from nutrigenomics can bring the nutritional sciences to a next level by providing more detailed insight into the processes of how nutrient intake leads to health status and diet-related diseases. It can also lead to a better understanding of individual differences in susceptibility to disorders related to dietary intake and metabolism. As such, nutrigenomics may eventually help maintain health and prevent disease and do so at an increasingly personalised level through specific insights into how an individual can adjust his dietary pattern to align with his genetic constitution. This application of genomics science in the consumer domain is called personalised nutrition. Personalised nutrition may take shape in both tailored nutritional advice and personalised food products, and has the potential of providing better health with 'just' nutrition as a tool. It is in line with the trend of personalisation in marketing more generally.

Nevertheless, the further development of nutrigenomics and personalised nutrition is not without its specific challenges. This is largely due to the fact that nutrigenomics is still an emerging science and that stakeholder opinions, including those of the consumer, are still under construction. As a consequence, different stakeholders – both expert and lay – may still have quite diverging and unstable views on the meaning, potential, and acceptability of nutrigenomics as a science and in terms of the innovations that emerge from it, such as personalised nutrition. This dissertation takes up the challenge of understanding and anticipating public perceptions and acceptance of nutrigenomics-based personalised nutrition at an early stage of its development. We approach the issue from a multi-stakeholder perspective in which we include both expert stakeholder views on critical success and failure factors for the further development of nutrigenomics-based personalised nutrition, and consumer evaluations of different scenarios under which personalised nutrition may enter the market place. The central research question to be answered by this thesis is: What determines public acceptance of nutrigenomics-based personalised nutrition? For this purpose, three lines of research are explored: (1) conceptual analysis based on integration of theoretical insights from previous scientific work, (2) expert views and their expectations on the future of genomics-based personalised nutrition, and (3) consumer perceptions and evaluations of different scenarios under which personalised nutrition might enter the market place.

Within the first line of research, previous scientific work is reviewed and integrated to arrive at a conceptual framework for consumer acceptance of technology-based food innovations. *Chapter 2* analyses the concept of personalisation in-depth using marketing and consumer behaviour literature. It puts the adjustment of products and services to personal consumer needs in a historical perspective, reviews process models for personalisation, and defines personalised nutrition as a value exchange in the interaction between the company and the individual consumer. Also, the specific costs and benefits of personalising nutrition for both the firm and the consumer side of the interaction are explicated. The costs for the company are those related to the resources required to deliver personalised offerings, with potential returns in terms of a price premium they may charge for personalised products and advices, improved customer relationships that may arise from personalisation and ultimately an enhanced brand image. For consumers, the main costs are a potential loss of taste as their favourite foods may not be part of the personalised advice, loss of convenience in meal preparation due to diversity in the family dinner, privacy concerns with respect to making intimate genetic information available to others, and the higher price they would have to pay for personalised solutions. In addition to health improvement, the benefits to consumers may also arise from the simplification of the choice process as well as the value they may derive from co-designing the marketing offering and participating in the interactive process.

Chapter 3 focuses on the consumer perspective arguing that genomics-based personalised nutrition is an example of a technology-based food innovation. It reviews previous research into acceptance of innovations from both inside and outside the food domain, extracts key learnings from this literature and integrates them into a new conceptual framework for consumer acceptance of technology-based food innovations. The framework distinguishes 'distal' and 'proximal' determinants of acceptance. The distal factors (characteristics of the innovation, the consumer and the social system) influence consumers' intention to accept an innovation through an identified set of proximal factors (perceived cost/benefit considerations, perceptions of risk and uncertainty, social norm and perceived behavioural control). The framework's use is demonstrated for genomics-based personalised nutrition by specifying qualitatively how it would apply to this particular innovation.

Within the second line of research, insights and expectations from the field of expert stakeholders are collected, integrated and used to shed light on potential development directions for nutrigenomics. *Chapter 4* elaborates on expert stakeholder views on the critical factors for nutrigenomics and personalised nutrition. Their views are elicited through 29 semi-structured interviews with Dutch experts in the field, covering a wide range of stakeholders from industry, government, science, health care, NGOs, and media. The results reveal that currently there is limited consensus between expert stakeholders about what nutrigenomics is and is not, the time needed for the field and its applications to develop and the factors that will determine market success or failure.

Within the third line of research, consumer opinions and preferences are explored in dedicated consumer research. Building on the conceptual framework (*chapter 3*) and the expert views (*chapter 4*), *chapter 5* develops systematically varied scenarios for the future of nutrigenomics-based personalised nutrition, and uses these to empirically test a set of key hypotheses on public acceptance of personalised nutrition within a representative sample of Dutch consumers. The results confirm that public acceptance is enhanced if consumers can make their genetic profiles available free at their own choice, if expert stakeholders communicate univocally about nutrigenomics, if the actual spin-off products provide a clearly recognisable advantage to the consumer and are easy to implement into the consumer's daily routines. Additionally, an exploratory segmentation analysis indicates that people have different focal points in their preferences for alternative scenarios of personalised nutrition.

Chapter 6 brings together expert and consumer views on the future of nutrigenomics in terms of both likelihood and desirability. Using the methodology of Group Decision Room, experts are confronted with how their views relate to consumer views on personalised nutrition, in an attempt to further detail and reconsider their opinions. The results show that expert stakeholders are well aware of consumer preferences, but that they do not expect nutrigenomics to develop fully in line with those preferences. Specifically, experts do not deem the consumer-desired consensus between stakeholders on the potential and value of nutrigenomics likely, nor that nutrigenomics-based products and services will be easy to implement in daily life as desired by consumers. Furthermore, the experts agree that it is crucial for them to be transparent to the public about their views on nutrigenomics.

Finally, *chapter 7* provides a general discussion of the results and an analysis of the marketing potential of nutrigenomics-based personalised nutrition, together with an analysis of limitations of the study and recommendations for future studies. The results suggest that if consumer needs and concerns (e.g. guaranteed freedom of choice) are addressed, there seems to be a basis for consumer acceptance of personalised nutrition. Still, there are many hurdles to be overcome, both from a technical-scientific and a marketing perspective, before gene-based personalised nutrition can become mainstream in the consumer market. Promising avenues for further research include longitudinal and cross-cultural examination of consumers' evaluation criteria for personalised nutrition, further consumer segmentation analyses, and an examination of the exact added value of visual stimulus material in researching consumer attitudes towards future events.

In conclusion, this thesis contributes to a better understanding of how public acceptance of the scientific innovation of nutrigenomics-based personalised nutrition comes about. It shows how issues critical for the further development of such an emerging science and the innovations arising from it can be systematically identified and addressed. The results reveal that freedom of choice, clear advantages, ease of applying personalised nutrition, and consensus among experts are important factors in enhancing consumer acceptance. However, the research in this thesis also shows that experts have not yet reached the necessary consensus on the scope and potential of nutrigenomics, and that experts do not expect that it will be easy for consumers to incorporate personalised nutrition into their daily life. These, and other, issues can serve as inspiration for future research, as well as the further refinement of the generic conceptual framework for consumer acceptance of food innovations.

SAMENVATTING

De voedingswetenschap levert steeds meer en steeds specifiekere kennis op over de reactie van het menselijk lichaam op voedingsstoffen. Een recente en veelbelovende wetenschappelijke discipline is nutrigenomics. Nutrigenomics richt zich op de interactie tussen voedingsstoffen en het humaan genoom, met het oog op gezondheid en ziekte. Het wordt door velen gezien als een doorbraak in voedingswetenschappen, omdat het op zeer gedetailleerd niveau inzicht verschaft in de invloed van voedingscomponenten op gezondheidsstatus en de achterliggende mechanismen. Ook kan nutrigenomics helpen een beter begrip te krijgen van verschillen tussen individuen voor wat betreft vatbaarheid voor aandoeningen die gerelateerd zijn aan voedselinname en metabolisme.

Uiteindelijk moet nutrigenomics bijdragen aan gezondheidsbehoud en ziektepreventie door inzichten te leveren over specifieke aanpassingen in het eetpatroon van een individu aan zijn of haar genetische constitutie. Deze toepassing van genomics wetenschap in het consumentendomein heet 'gepersonaliseerde voeding'. Gepersonaliseerde voeding kan gestalte krijgen in zowel voedingsadvies op maat als gepersonaliseerde voedselproducten, en heeft de potentie om gezondheid te verbeteren met 'slechts' voeding als middel. Dit sluit aan bij een meer algemene marketing trend van personalisatie.

Echter, de verdere ontwikkeling van nutrigenomics en gepersonaliseerde voeding kent specifieke uitdagingen. Nutrigenomics is een opkomende wetenschap en de meningen van belanghebbenden (ofwel stakeholders) zijn vaak nog niet uitgekristalliseerd. De verschillende stakeholders – zowel experts als leken – kunnen nog uiteenlopende en veranderlijke visies hebben op de betekenis, de potentie en de aanvaardbaarheid van nutrigenomics als wetenschap en van de innovaties die eruit voortvloeien, zoals voorgenoemde gepersonaliseerde voeding. Dit proefschrift richt zich op het begrijpen van publieke percepties en acceptatie van op nutrigenomics gebaseerde gepersonaliseerde voeding, nu deze innovatie nog in een vroeg stadium is. We benaderen het onderwerp vanuit een multi-stakeholder perspectief; zowel de visie van expert stakeholders als de perceptie en het oordeel van de consument komen in dit proefschrift aan bod.

De centrale onderzoeksvraag die dit proefschrift tracht te beantwoorden luidt: *Wat bepaalt publieke acceptatie van op nutrigenomics gebaseerde gepersonaliseerde voeding?* Hiertoe worden drie onderzoekslijnen gevolgd: (1) conceptuele analyse op basis van een integratie van theoretische inzichten uit eerder wetenschappelijk werk, (2) de visie van experts op kritieke succes- en faalfactoren en de verwachtingen voor de toekomst van op genomics gebaseerde gepersonaliseerde voeding, en (3) consumentenpercepties en -oordelen over verschillende scenario's voor het op de markt komen van gepersonaliseerde voeding.

Binnen de eerste onderzoekslijn wordt eerder wetenschappelijk onderzoek besproken en geïntegreerd om te komen tot een conceptueel raamwerk voor consumentenacceptatie van op technologie gebaseerde voedselinnovaties. In *hoofdstuk 2* wordt het concept van personalisatie in detail uiteengezet met behulp van literatuur op het gebied van marketing en consumentengedrag. Het zet de aanpassing van producten en diensten aan consumentenbehoeftes in een historisch perspectief en definieert personalisatie als een interactief proces tussen het bedrijf en de individuele consument. Daarnaast worden de specifieke voor- en nadelen van het personaliseren van voeding uitgewerkt voor zowel bedrijven als consumenten. De nadelen voor bedrijven betreffen de extra kosten van benodigde hulpbronnen om gepersonaliseerde producten te leveren. Daartegenover staan voordelen in de vorm van een meerprijs die gerekend kan worden voor gepersonaliseerde producten en diensten, verbeterde klantrelaties dankzij personalisatie en uiteindelijk een beter imago. Voor consumenten zijn de belangrijkste nadelen een eventueel verlies aan keuzemogelijkheden als bepaalde voedingsmiddelen geen deel uitmaken van het gepersonaliseerde advies, verlies van gemak als voor verschillende gezinsleden verschillende maaltijden bereid moeten worden, zorgen om de privacygevoeligheid van hun genetische informatie en de hogere prijs van gepersonaliseerde producten. Voordelen voor de consument, naast gezondheidsbehoud, kunnen liggen in de vereenvoudiging van het keuzeproces en de mogelijk positieve ervaring van het kunnen meebepalen en -ontwerpen van een product.

Hoofdstuk 3 plaatst de acceptatie van op genomics gebaseerde gepersonaliseerde voeding in een breder perspectief. Het bespreekt eerder onderzoek naar consumentenacceptatie van technologische innovaties – zowel binnen als buiten het domein van voeding –, extraheert de kernbegrippen hieruit en integreert deze tot een nieuw conceptueel raamwerk voor consumentenacceptatie van op technologie gebaseerde voedselinnovatie. Het raamwerk onderscheidt 'distale' en 'proximale' factoren die de acceptatie bepalen. De distale factoren (eigenschappen van de innovatie, de consument en het sociale systeem) beïnvloeden de intentie van consumenten om een innovatie te accepteren via een vaste set van proximale factoren (percepties van kosten/baten afwegingen, percepties van risico en onzekerheid, sociale norm en percepties van gedragscontrole). Het gebruik van dit raamwerk is vervolgens geïllustreerd door de distale en proximale factoren kwalitatief te specificeren voor op genomics gebaseerde gepersonaliseerde voeding.

Binnen de tweede onderzoekslijn zijn inzichten en verwachtingen vanuit het veld van expert stakeholders verzameld, geïntegreerd en gebruikt om zicht te krijgen op eventuele ontwikkelingsrichtingen voor nutrigenomics. *Hoofdstuk 4* gaat in op visies van expert stakeholders op de kritieke succes- en faalfactoren voor nutrigenomics en gepersonaliseerde voeding. Deze visies zijn verkregen middels 29 semi-gestructureerde interviews met Nederlandse experts op het gebied, die een breed spectrum aan stakeholders vertegenwoordigen uit bedrijfsleven, overheid, wetenschap, gezondheidszorg, niet-gouvernementele organisaties en media. De resultaten laten zien dat er momenteel nog weinig overeenstemming bestaat tussen expert stakeholders over (a) wat nutrigenomics is en wat niet, (b) de tijd die nodig is voor de ontwikkeling van de discipline en diens toepassingen en (c) de factoren die marktsucces of –falen zullen bepalen.

Binnen de derde onderzoekslijn zijn de opinies en voorkeuren van consumenten onderzocht. Voortbouwend op het conceptuele raamwerk (*hoofdstuk 3*) en de expert visies (*hoofdstuk 4*), ontwikkelt *hoofdstuk 5* systematisch gevarieerde scenario's voor de toekomst van op nutrigenomics gebaseerde gepersonaliseerde voeding. Deze scenario's zijn gebruikt om een aantal specifieke hypotheses te toetsen over publieke acceptatie van gepersonaliseerde voeding in een representatieve steekproef van Nederlandse consumenten. De resultaten bevestigen dat publieke acceptatie gestimuleerd wordt als consumenten zelf kunnen kiezen om hun genetisch profiel al dan niet te laten vaststellen, als expert stakeholders eenduidig communiceren over nutrigenomics en als de daadwerkelijke producten een duidelijk herkenbaar voordeel bieden aan consumenten en gemakkelijk toe te passen zijn in hun dagelijkse routines. Daarnaast laat een verkennende segmentatie-analyse zien dat groepen mensen niet alleen verschillen in hun oordeel over verschillende scenario's voor gepersonaliseerde voeding, maar ook in de manier waarop dit oordeel tot stand komt.

Hoofdstuk 6 brengt expertvisies en consumentenoordelen met betrekking tot de toekomst van nutrigenomics samen. Door middel van de 'Group Decision Room' methodiek werden experts geconfronteerd met de eerder gevonden consumentenpercepties van gepersonaliseerde voeding. De resultaten laten zien dat expert stakeholders zich terdege bewust zijn van de voorkeuren van consumenten, maar dat zij niet verwachten dat nutrigenomics zich volledig in lijn met die preferenties zal ontwikkelen. Experts achten de door consumenten gewenste consensus tussen experts over de mogelijkheden en waarde van nutrigenomics namelijk niet waarschijnlijk, evenmin als gemakkelijke inpasbaarheid van gepersonaliseerde voeding in het dagelijks leven. Verder zijn de experts het er over eens dat het belangrijk is dat zij transparant zijn naar het publiek over hun visie op nutrigenomics.

Hoofdstuk 7, tot slot, geeft een algemene discussie van de resultaten en een analyse van de marketingmogelijkheden van op nutrigenomics gebaseerde gepersonaliseerde voeding, evenals een analyse van de beperkingen van het onderzoek en aanbevelingen voor toekomstige studies. De resultaten suggereren dat als er voldoende aandacht is voor de zorgen en behoeften van consumenten (bijvoorbeeld door keuzevrijheid te garanderen), er een basis lijkt te zijn voor consumentenacceptatie van gepersonaliseerde voeding. Er moeten echter nog vele hordes genomen worden, zowel in technisch-wetenschappelijk als in marketing opzicht, voordat op genen gebaseerde gepersonaliseerde voeding op grote schaal gebruikt kan worden door de consument. Veelbelovende richtingen voor verder onderzoek zijn longitudinaal en cultuurvergelijkend onderzoek naar evaluatiecriteria van consumenten voor gepersonaliseerde voeding, verdere consumentensegmentatie, en onderzoek naar de precieze toegevoegde waarde van visueel stimulusmateriaal in het bestuderen van de houding van consumenten ten opzichte van toekomstige gebeurtenissen.

Dit proefschrift draagt bij aan een beter begrip van de totstandkoming van publieke acceptatie van op nutrigenomics gebaseerde gepersonaliseerde voeding. Het laat zien hoe kritieke factoren voor de verdere ontwikkeling van een dergelijke nieuwe wetenschap en de daaruit voortvloeiende innovaties systematisch kunnen worden geïdentificeerd. De resultaten laten zien dat keuzevrijheid, duidelijke voordelen, gemakkelijke toepasbaarheid van gepersonaliseerde voeding en consensus tussen experts belangrijke factoren zijn om consumentenacceptatie te bewerkstelligen. Tegelijkertijd toont het onderzoek in dit proefschrift aan dat experts nog niet de noodzakelijke consensus hebben bereikt over de reikwijdte en potentie van nutrigenomics, en dat experts niet verwachten dat het gemakkelijk zal zijn voor consumenten om gepersonaliseerde voeding toe te passen in hun dagelijks leven. Deze en andere kwesties kunnen, evenals het verder verfijnen van het conceptuele raamwerk voor consumentenacceptatie van voedselinnovaties, dienen als bron van inspiratie voor toekomstig onderzoek.

List of Publications

Journal papers

Ronteltap, A., van Trijp, J.C.M. & Renes, R.J. (in press). Consumer acceptance of nutrigenomics-based personalised nutrition. British Journal of Nutrition. doi:10.1017/S0007114508992552.

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Book chapters

van Trijp, J.C.M., & Ronteltap, A. (2007). A marketing and consumer behaviour perspective on personalised nutrition. In F. J. Kok, L. Bouwman & F. Desiere (Eds.), Personalized nutrition: Principles and applications, p185-204. Boca Raton (FL): CRC Press.

Ronteltap, A., Wendel, S., van Trijp, H.C.M., and Dellaert, B.G.C. (2006). Marketing van producten die passen bij de genetische structuur van het individu (Marketing Products that Match the Genetic Structure of the Individual). in: A.E. Bronner, P. Dekker, E. de Leeuw, K. de Ruyter, A. Smidts and J.E. Wieringa eds. Ontwikkelingen in het Marktonderzoek: Jaarboek 2006 MarktOnderzoekAssociatie (in Dutch), Haarlem: De Vrieseborch.

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Presentations

Ronteltap, Amber, Renes, Reint Jan, and Van Trijp, Hans (2007). Nutrigenomics: which future do consumers prefer? Presented at the 16th SRA Europe Conference: Building bridges, issues for future risk research, June 19, Den Haag, the Netherlands

Ronteltap, Amber (2006). Understanding consumer acceptance of nutrigenomics. Presented at the 2nd Corsage Winter Symposium: Genomics in Society, from intentions to implementations, November 24, Wageningen, the Netherlands.

Ronteltap, Amber and Van Trijp, Hans (2006). Seeing the future of personalised nutrition. Presented at the 4th International MAPP Workshop on Consumer Behaviour and Food Marketing: Food Innovation and New Product Development, May 29-30, Middelfart, Denmark.

Ronteltap, Amber and Van Trijp, Hans (2005). Consumer acceptance of personalized nutrition. Presented at the 3rd International Nutrigenomics Conference (NuGo) From Nutrigenomics to Personalised Nutrition, November 2-4, Palma de Mallorca, Spain.

Ronteltap, Amber (2004). Seeing the future first and most clearly: an experimental approach to information acceleration for nutrigenomics. Presented at doctoral colloquium of 33rd EMAC (European Marketing Academy Conference), May 16-18, Murcia, Spain.

Ronteltap, Amber, Van Trijp, Hans, Frewer, Lynn, Renes, Reint Jan (2003). Seeing the future first and most clearly: an experimental approach to information acceleration for nutrigenomics. Presented at 7th PFGS (Postgraduate Forum on Genetics and Society) Colloquium: "Hope, Hype and Hysteria: Living with genetic uncertainty." August 20-22, University of Sussex, UK.

CURRICULUM VITAE

Amber Ronteltap was born in Wissenkerke (Noord-Beveland, the Netherlands) on September 12, 1979. She attended the secondary school 'SSG Het Goese Lyceum' where she received her diploma in 1997. That same year, she started to study Human Nutrition and Health at Wageningen University. She specialised in nutrition sciences and marketing and consumer behaviour, which illustrates her affinity with both the natural and the social sciences. The first of her theses was in cooperation with the academic hospital UMC Utrecht on standardising diagnostic methods for food allergy, of which the results were published in the journal *Allergy*. Her second thesis concerned an analysis of the opportunities for the market for organic under the authority of a fruit-importing company. After graduating in 2001, she worked in several project-based jobs and in April 2003, she started her PhD research at the Marketing and Consumer Behaviour Group of Wageningen University and Research Centre. As of April 2008 she is working as a consumer researcher at the agricultural economics institute (LEI Wageningen UR).

COMPLETED TRAINING AND SUPERVISION PLAN

Description	Institute / Department	Year	ECTS*
Courses:			
Research methodology: Designing and conducting a PhD research project	Mansholt Graduate School of Social Sciences (MG3S)	2003	2.8
Scientific writing	CENTA Language Centre	2003	2.1
Mansholt Introduction course	MG3S	2003	1.4
Master Class "License to life sciences"	Swammerdam Institute for Life Sciences & Schuttelaar&Partners	2003	1.4
Multivariate Analysis Techniques	WUR (D300-217)	2003	5.6
Ethics for life scientists	MG3S	2003	2.8
Food perception and food preference	Graduate School Voeding, Levensmiddelentechnologie, Agrobiotechnologie en Gezondheid (VLAG)	2003	1.4
Experimental, quasi-experimental and correlational research: continuous and categorical designs.	Interuniversity Graduate School of Psychometrics and Sociometrics (IOPS)	2004	1
Introduction in Advanced Quantitative Research Methods for 1st year PhD students in Business	University of Maastricht & Technical University Eindhoven	2004/2005	13
Rathenau TA Zomerschool	Technical University Delft & Rathenau Institute	2006	1.8
Presentations at conferences and workshops:			
Doctoral colloquium of 33rd EMAC (Marketing) Conference, Murcia, Spain		2004	1.4
3rd International Nutrigenomics Conference (NuGo), Palma de Mallorca		2005	1.4
Mansholt Multidisciplinary seminar		2006	1.4
16th SRA (Risk Analysis) Europe conference, Scheveningen		2007	1.4
Teaching and supervising activities:			
MSc Thesis Ellis Vyth		2004/2005	2
MCB30804/6 Sensory perception and consumer preference		2004/05/06/07	1
CIS33306 Risk Communication		2005/06/07	1
Total (minimum 30 ECTS)			**42.9**

*One ECTS on average is equivalent to 28 hours of course work

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