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THE ROLE OF INFORMATION IN HEALTH-RELATED FOOD QUALITY PERCEPTIONS AND FOOD CHOICES

Thesis submitted in fulfillment of the requirements for the degree of Doctor (PhD) in Applied Biological Sciences

Dutch translation of the title:

De rol van informatie in gezondheidsgerelateerde kwaliteitspercepties en voedingskeuzes

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Woord vooraf

Naar deze dag heb ik zolang uitgekeken! Eindelijk is het zover, mijn doctoraat is af! Graag blik ik terug op deze boeiende en uitdagende maar toch ook inspannende afgelopen vijf jaar waarin heel wat mensen me op uiteenlopende manieren hebben bijgestaan en gemotiveerd. Ik wil dan ook graag van deze gelegenheid gebruik maken om een aantal mensen speciaal te bedanken.

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Bedankt allemaal!

Christine, september 2011

Table of contents

List of abbreviations

ADI	Acceptable daily intake
ANCOVA	Analysis of covariance
BMI	Body mass index
bw	Body weight
C/N	Carbon/nitrogen
CI	Confidence interval
DRI(s)	Dietary reference intake(s)
EU	European Union
EuroFIR	European Food Information Resource Network
FAFH	Food away from home
FAO	Food and Agriculture Organization
FFQ	Food frequency questionnaire
FOP	Front-of-pack
FW	Fresh weight
GDA	Guideline daily amounts
GDBH	Growth/differentiation balance hypothesis
GLM	General Linear Factorial Model
JECFA	Join FAO/WHO Expert Committee on Food Additives
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
LOD	Limit of detection
LOQ	Limit of quantification
MNL	Multinomial Logit model
NDs	Non-detects
OH	Out-of-home
POP	Point-of-purchase
SAFA	Saturated fatty acid
SD	Standard deviation
SE	Standard error
SEM	Structural equation modelling
TDI	Tolerable daily intake
TL	Traffic light label
WHO	World Health Organization
WTP	Willingness-to-pay

PART I

General introduction

Chapter 1

Introduction, objectives and outline of the thesis

1.1 Relevance of the topic

1.1.1 Health-related food trends

The food choices consumers make determine which nutrients and other components (e.g. contaminants) enter the body and influence health. Scientific evidence strongly supports the causal relationship between diet and health (Bray & Popkin, 1998; Hu & Willett, 2002; Key et al., 2004; Reddy & Katan, 2004; Steyn et al., 2004; Swinburn et al., 2004; Willett & Trichopoulos, 1996) and has led to the formulation of dietary recommendations to the public (WHO, 2003). The relation between diet, health and lifestyle is a key priority for food and public health policy because of the rising incidence of diet-related non-communicable chronic diseases such as obesity, cardiovascular diseases and certain types of cancer (WHO, 2011a). With the public's increased awareness of causative and preventive effects of certain foods on health, *health*-related food qualities have been of increasing importance for consumer food choice (Grunert, 2006). Where previously sensory qualities (taste, appearance and smell) were the most important choice criteria, today health is equally valued, followed by process and convenience food aspects (Grunert, 2006). Consumers distinguish between two main health dimensions: eating healthy which relates to the nutritional aspects of foods, and avoiding unhealthy foods dealing with concerns about food safety (Brunsø et al., 2002). Being one of the basic human values, health motivates consumer behaviour by contributing to values like security (i.e. absence of illness) and preceding values like hedonism (Schwartz, 1992). Since health is an invisible product characteristic, consumers may infer the healthiness of a food from other quality aspects such as process and convenience characteristics of the food.

The *process*-related quality of a food refers to the way a food has been produced such as organic food production (Grunert et al., 1996). While the interest in food production methods has been growing for some time, this interest has been intensified by the recent food scandals and the resulting food scares (Tregear et al., 1994). The trend for organic food in particular has emerged out of consumers' concerns for their health and for the environment with health being more important than the environmental concerns (Magnusson et al., 2003). In other words, consumers' motives to buy organic foods appear to arise mainly from the product-specific characteristics directly benefiting the consumers rather than the process-specific characteristics indirectly benefiting the consumers. Organic farming has become one of the fastest growing sectors in agriculture with a worldwide growth of 82% between 2006 and 2008 (Willer & Youssefi, 2007). The evolution of the organic food retail sales in Belgium and the four largest markets in the EU are presented in Figure 1.1. Consumers associate organic foods not only with health and the environment, but also with a higher price, purity (i.e. full or almost additive free), cleanliness (i.e. pesticide free and free from other chemicals) and better animal welfare (Roininen et al., 2006).

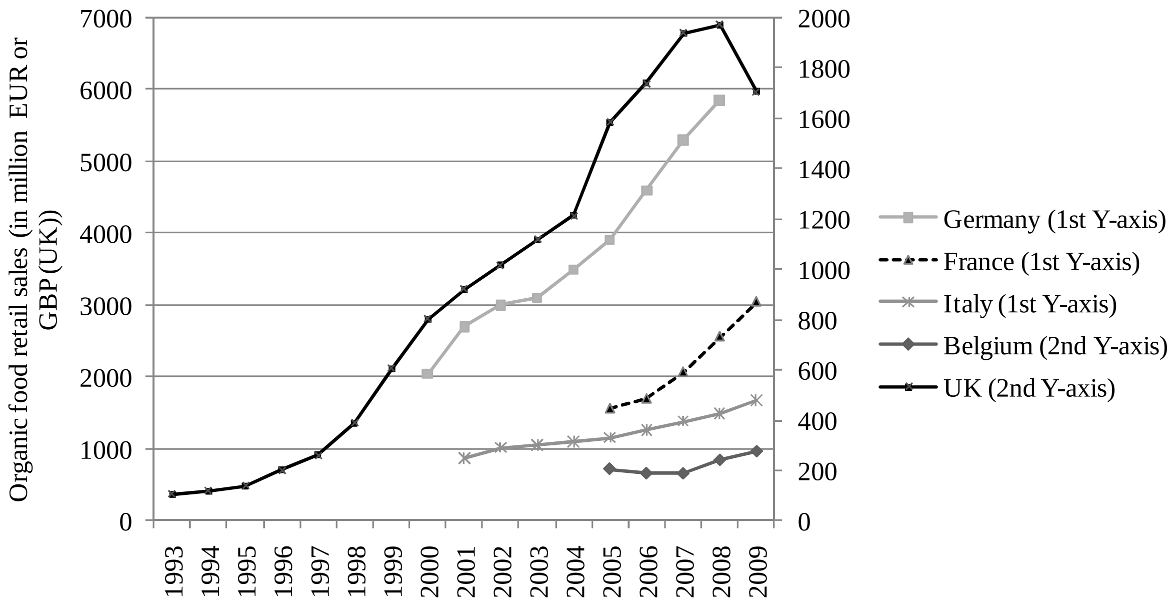

Figure 1.1 Evolution of organic food retail sales in selected European countries (1993-2009)
Source: EC Directorate General for Agriculture and Rural Development (2010)

Convenience has gained considerable importance in the food choices of today's consumers due to rising incomes, the increased participation of women in the work force, but more importantly consumers' perception of monetary and time constraints (Scholderer & Grunert, 2005; Wales, 2009). Convenience refers to food aspects which save time, mental and physical effort during food purchase, storage, preparation and consumption (Gofton, 1995; Grunert, 2006). Convenience food products relate to various home meal substitutes including the so-called food away from home (FAFH) (Costa et al., 2001). FAFH is defined as food prepared out of home irrespective of the place of consumption, or alternatively, food consumed out of home irrespective of the place of preparation (Naska et al., 2011). The increased FAFH consumption in Belgium and selected European countries is illustrated by means of expenses for catering services in Figure 1.2. Previously the group of convenience-oriented consumers was rather limited to consumers who were not very interested in the taste, health or process-related quality of foods. Today the convenience-oriented consumer segment is extended to consumers demanding foods which are not only convenient but also have good taste, health and process qualities (Brunsø et al., 2002).

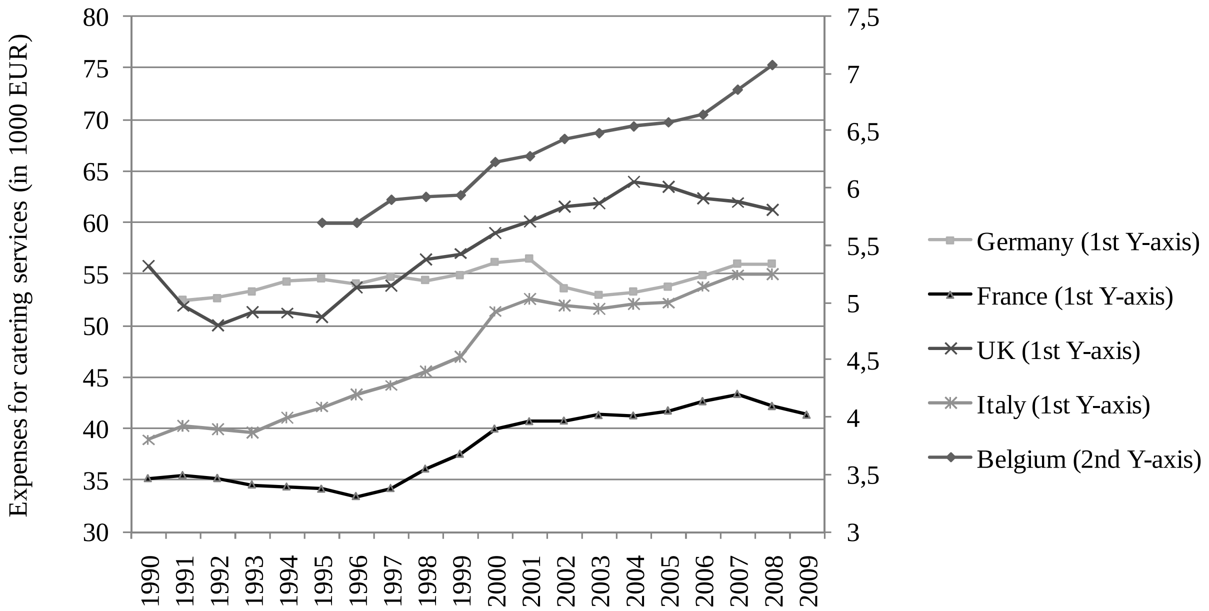

Figure 1.2 Evolution of expenses for catering services in selected European countries (1990-2009). Prices adjusted to the levels of 2000. Source: OECD (2011)

1.1.2 Relevance and effectiveness of nutrition and health communication

Food choices and quality perceptions are important because they create consumer demand for suppliers in the food chain who produce, process and distribute food (Sobal et al., 1998). Although consumers are increasingly demanding healthier products, the worldwide growing prevalence of diet-related non-communicable chronic diseases suggests that many consumers seem to struggle with making healthier food choices. A major obstacle is the fact that consumers may not directly perceive or verify the healthiness of a food either before nor after consumption, but they need to infer it from various information sources (Caswell & Mojduszka, 1996). In other words, there exists information asymmetry between consumers and other stakeholders such as the food producer and government (Verbeke, 2005). Nutrition and health communication about the nutritional properties and associated health effects is necessary for consumers to search and select healthier foods (Drichoutis et al., 2006).

Effective communication depends largely on the degree to which the information is adequately processed. An important prerequisite for information effectiveness is that consumers are able and willing to process information (Moorman, 1990). The level of nutrition knowledge which determines consumers’ ability to process the communication, is often insufficient to adequately understand specific nutrition information (Grunert & Wills, 2007). Since many food choices are low involvement decisions, i.e. of low personal relevance or risk of wrong decisions, consumers tend to use simple rules of thumb (i.e. heuristics or cues) to make up their food decision (Chaiken, 1980; Petty & Cacioppo, 1986). Additionally, consumers are exposed to plenty of information urging them to choose or not to choose a food product. This means that information is processed in continuous interaction with other information, resulting in associations which may go beyond its literal and even intended meaning (van Trijp, 2009).

1.1.3 The importance of nutrition labelling to different stakeholders

(based on Möser et al. (2010))

One of the major instruments to provide nutrition information is food labelling (Grunert & Wills, 2007). Nutrition labelling is an attractive instrument since it provides information while retaining consumer freedom of choice and it reduces information search costs. Consumers' increased demand for information about the health characteristics of foods has motivated food manufacturers and retailers to provide nutrition information on their food labels (Verbeke, 2005). Different front-of-pack (FOP) simplified nutrition labels have recently been introduced voluntarily as a complementary scheme to the European Union (EU) regulated back-of-pack nutrition table (EC Regulation 90/496), and nutrition and health claims on prepacked foods (EC Regulation 1924/2006). Examples are the guideline daily amounts and traffic light label (European Heart Network, 2007). These simplified nutrition labels differ from the traditional nutrition tables in the amount and presentation of the nutrition information and therefore, would require less time and effort to be processed.

From a *consumer* point of view, nutrition labels are important information cues that can guide their food choices, and enable them to make better informed and healthier food choices. In other words, nutrition labels are signals of health-related food quality, and foods without such a label may alert consumers about its absence (Golan et al., 2001). Nutrition labels and more specifically the simplified nutrition labels may reduce the information search and acquisition costs and as such increase their usage. Provided that the information is correct, complete, trustworthy and correctly understood, nutrition labels can increase the efficiency and the utility of purchase decisions (Teisl et al., 2001). For example, in the case of consumers with hypertension, labels may help them to reduce their salt intake by eating foods labelled as "low salt". However, negative spill-over effects may occur if consumers substitute information from objective sources such as doctors by nutrition labels which are probably less scientifically correct and perhaps so designed that they favour a labelled product (Calfee & Pappalardo, 1991). For example, a food label with information based on small portion sizes compared to a normal portion size, may lead to overconsumption of the respective product.

Additionally, nutrition labelling can create resistance in consumers when they feel directed to choices they do not want to make (Grunert & Wills, 2007).

For *policy makers*, providing consumers with summarised nutrition information on food labels may lead to an increase in informed food choices and socially desirable changes in consumption behaviour (Golan et al., 2001). Moreover, nutrition labelling is an important tool for reducing information asymmetry and to ensure transparency in the food market (Grunert, 2002). By regulating nutrition information, food reformulation and innovation as well as fair competition can be stimulated (EC Regulation 1924/2006). However, labelling induces costs including costs of program initiation, administration and enforcement (Golan et al., 2001).

The *food industry* has an interest in nutrition labelling to develop strategies to better differentiate their food products in the market and hence to build and maintain health-oriented competitive advantages (Caswell & Mojduszka, 1996). Nutrition labels allow firms to make their corporate social responsibility visible to the public (van Trijp, 2009). However, labels may have a “public good” character, implying that additional information provided by one firm may be advantageous to all other firms in the market (Golan et al., 2001). Simplified nutrition labelling can increase market performance. In case simplified nutrition labelling becomes mandatory, (more) consumers may become aware of the lower nutritional value of one food compared to another, leading to possible shifts in their demand and the survival probability of certain food products if these products are not reformulated according to the requirements of healthy nutrition (Rubin, 2008). Additionally, mandatory nutrition labelling can induce food innovations (Drichoutis et al., 2006). It may nevertheless result in higher costs due to new designs of packages, new information provided in printed and internet media as well as costs induced by product formulation changes.

1.2 Scope of the doctoral thesis

In this doctoral dissertation, the health-related quality is approached from a multidisciplinary perspective, incorporating theories and methodologies from food and nutrition science on the one hand and consumer science on the other hand. Two case studies are presented in this doctoral dissertation, one dealing with organic vegetables, the other with out-of-home (OH) meals, which both exemplify important food trends in the last two decades. In both case studies the role of information, i.e. an organic claim and simplified nutrition information, is studied in the formation of health-related food quality perceptions and food choices. Prior to the empirical studies, a scientific justification of the organic claim is provided, while in the case of the OH meals a simplified nutrition label is developed based on existing meal recommendations. The terms "nutrition information" and "nutrition label" are used interchangeably throughout the dissertation. They both refer to the information about the nutrient content of OH meals. The research is focused on Flanders, the Northern part of Belgium, which is characterized by a western lifestyle and related organic and OH food consumption trends.

1.2.1 Case study 1: Organic vegetables

The first case study was part of a research project (2006-2007) on the comparison of organic vegetables and farming with the conventional alternative regarding their environment friendliness, nutritional value and safety, and this both from a scientific and consumer perspective (Van Huylenbroeck et al., 2009). The project including this case focused on a single food group with a healthy image, namely vegetables (including potato). Although potatoes are, strictly speaking, no vegetables, for the purpose of this dissertation potato is considered as one of the five vegetables (next to carrot, tomato, lettuce and spinach) as according to the Codex Classification (Codex Alimentarius, 1993). The focus on vegetables is primarily motivated by their importance in the organic foods market in Belgium with a market share in 2009 of 29% in terms of volume and a market penetration of 51% (provided by GfK Panelservices Benelux). Vegetables are an important source of micronutrients including vitamins, minerals and various beneficial phytochemicals, which are considered to be responsible for their protective effect against chronic diseases such as certain cancers (Hung et al., 2004). At the same time vegetables are also a potential source of human exposure to contaminants such as nitrates, heavy metals, pesticide residues and pathogenic micro-organisms (cf. recent outbreak of enterohaemorrhagic *E. coli* (EHEC) in Germany; WHO (2011b)) (Dedaza & Diaz, 1994). In order to compare the health-related quality and its perception between organic and conventional vegetables among adults with varying consumption of organic vegetables, both dimensions of health, i.e. the nutritional and safety aspects, are considered in this dissertation.

1.2.2 Case study 2: Nutrition information on university canteen meals

The second case study (2008-2011) is positioned in a specific OH context, namely two canteens of Ghent University. The canteen of the Faculty of Bioscience Engineering and the one of the Faculty of Psychology and Educational sciences have been selected because of logistic advantages and their similarity in size and number of customers, and their equal meal offer. Both canteens serve about 225 hot meals a day. These canteens are representative for the other canteens of Ghent University since the same suppliers cater for all canteens and the menus are standardized. Canteen meals are composed of different processed food groups (e.g. meat, vegetables) and form an important part of the diet for many university students and staff. The consumption of canteen meals have been associated with food and nutrient intakes that contribute to the increased prevalence of diet-related non-communicable chronic diseases, such as higher intakes of energy, fat and sodium, and insufficient intakes of fruits and vegetables (Lachat et al., 2009). In contrast with the healthy image of vegetables, consumers are generally unaware of the lower nutritional quality of eating out compared to eating at home (Burton et al., 2006). They often base their health-related quality expectations of OH meals on their quality experiences with similar home-made meals (Costa et al., 2007). In this case study the health-related quality is approached by the nutrition-related dimension of health which for meals relies on both the composition and the quantity of its ingredients.

1.3 Conceptual framework

The conceptual framework of this doctoral dissertation (Figure 1.3) is based on the four food quality concepts (Grunert et al., 1996), the food quality perception process (Grunert et al., 1996; Steenkamp, 1990), an information response model (Grunert & Wills, 2007) and the quality quadrant (Oude Ophuis & van Trijp, 1995). These concepts and models are commonly used in research on consumers’ food quality perceptions and their impact on food choices. First, the concept of health-related food quality will be defined. Second, the way consumers form an overall judgement of food quality based on surrogate indicators of quality (or quality cues) will be explained. Finally, factors that influence health-related food quality will be discussed.

1.3.1 The concept of health-related food quality

Food quality is defined in many different ways but the two main different definitions are objective and subjective food quality (Oude Ophuis & van Trijp, 1995). Objective food quality refers to the technical, objective measurable and verifiable nature of food products and processes. The product-oriented quality covers the physical characteristics intrinsic to a food product (e.g. fat content), while the process-oriented quality includes the characteristics of the process by which a food product has been produced (e.g. organic) (Grunert et al., 1996). While these two types of objective food quality deal with the level of quality, a third type or quality control deals with the adherence of a food product to predetermined food standards. Subjective or perceived food quality covers the way consumers perceive food quality which may differ significantly from the objective food quality (Grunert, 2005).

The gap between objective and subjective food quality has been attributed to consumers' quality perception process or the so-called perception filter (Risvik, 2001). In order to understand this gap between scientific objectivity and human subjectivity with regard to food quality, two useful classifications of quality attributes for food have been proposed in the literature. A first distinction is made between intrinsic and extrinsic attributes (Olsen & Jacoby, 1972). The intrinsic quality attributes relate to the physical aspects of a food product (e.g. fat content, colour and taste), while the extrinsic quality attributes refer to food aspects which are physically not part of it (e.g. price, nutrition and production information). A second classification distinguishes between search, experience and credence attributes (Darby & Karni, 1973; Nelson, 1970, 1974). Search attributes can be verified before the actual purchase of the food product (e.g. colour, price), while experience attributes are only perceived after purchase (e.g. taste). In contrast, consumers may not find out whether the food product actually possesses credence attributes (e.g. fat content, organic production).

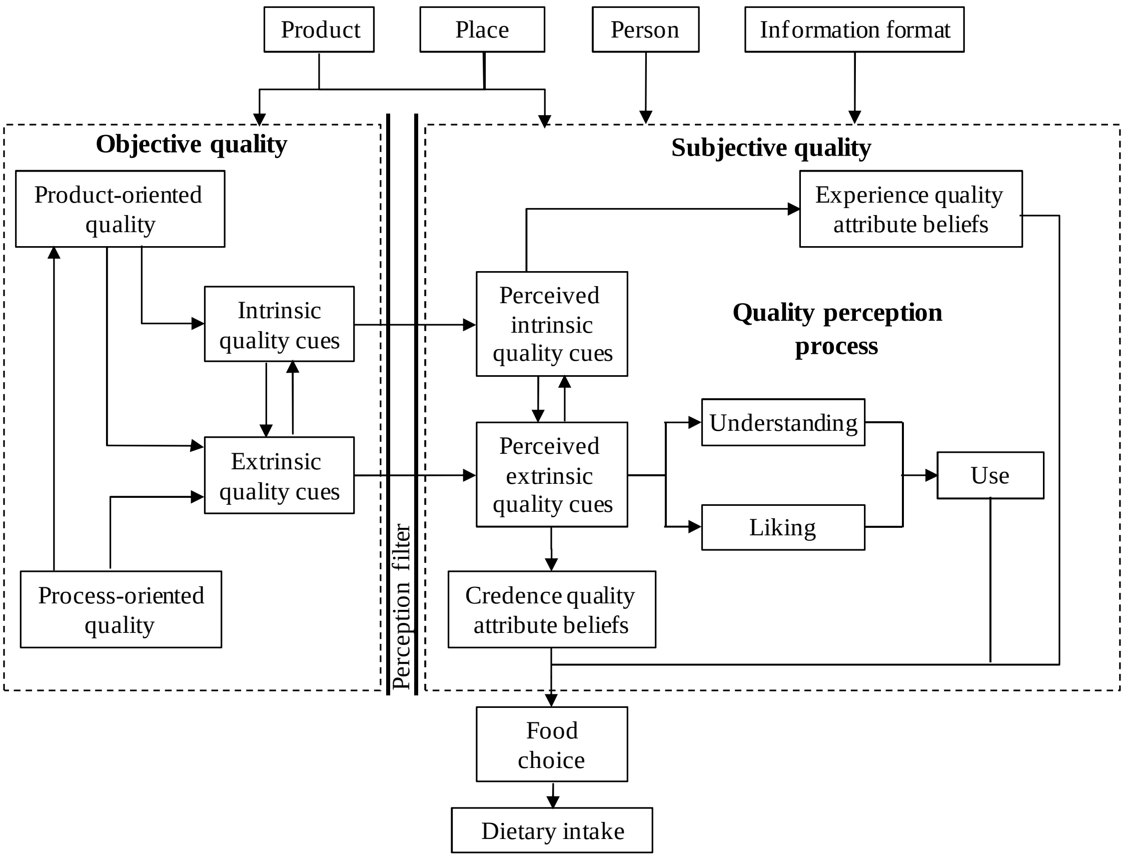

Figure 1.3 Conceptual framework

Finally, food quality is multidimensional. From a consumer perspective, food quality includes four dimensions: sensory value, health, convenience and process (Grunert et al., 1996). The sensory or hedonic quality dimension refers to food aspects such as the taste, appearance and smell, with taste as the principal aspect. Health-related qualities concern food aspects that consumers perceive to affect their health and is subdivided into the nutritional value and safety aspects of a food (Brunsø et al., 2002; Sikora & Strada, 2005). The process quality dimension relates to the process by which a food has been produced, while the convenience dimension covers food aspects that save time and effort. Where the sensory and convenience-related qualities are mostly search or experience characteristics, the health and process-related qualities are credence characteristics. This doctoral dissertation focuses on these credence quality attributes and more specific on the health-related qualities of food products and production processes.

1.3.2 Quality perception process and food choice

Since consumers are not able to perceive most food quality attributes before or even after purchase and consumption, they form expectations about the quality. These quality expectations are based on so-called quality cues, which are pieces of information related to the quality of a food that consumers may observe by their senses before purchase (Oude Ophuis & van Trijp, 1995; Steenkamp, 1990). Quality cues are categorized as either intrinsic or extrinsic and includes concrete product characteristics, mostly search attributes. The way consumers use quality cues to infer food quality can be quite complex and come across as being irrational sometimes (Brunsø et al., 2002). For example, consumers seem to use the colour of meat to infer tenderness. In order for quality cues to influence consumers' beliefs and attitudes towards the quality of a food, these cues need to be perceived by consumers (Grunert & Wills, 2007). Perception may result in understanding of the cues, which is the meaning a consumer gives to what is perceived in relation to earlier experiences and prior knowledge. This meaning is not necessarily the one intended by the quality cue. Consumers may also like the perceived cues without necessarily understanding them. Both understanding and liking of the quality cues are assumed to have an impact on its use. This hierarchy of effects from perception to cue or information utilization has been proposed by Grunert and Wills (2007) and is based on research in consumer decision-making (Engel et al., 1968) and attitude formation and change (Lavidge & Steiner, 1961). Cues that consumers use to form an overall judgment of the quality of a food, i.e. perceived quality, will eventually determine their food choice and dietary intake.

1.3.3 Factors influencing health-related food quality

The processes of quality perception and food choice may differ between persons, products and places (Oude Ophuis & van Trijp, 1995). Depending on the food product, different quality cues may be taken into account when judging the quality of a food. For example, nutrition information about the vitamin content may be relevant when judging fruits and vegetables, but less relevant in the case of meat. The quality perception process becomes even more complex when a combination of foods is considered, such as meals. Since individual differences occur in perceptual abilities, preferences and experience level, the perceived quality and food choice will vary accordingly. Also the place or environment in which a food is planned to be consumed may affect its perceived quality. Home-prepared meals are generally perceived more positively than meals consumed OH (Costa et al., 2007). Moreover, the way quality cues such as nutrition information are presented may influence consumers' perceived healthiness of a food. For example, nutrition information by means of graphics, symbols, verbal descriptors (high, medium, low) and with limited numerical information have been shown to increase consumers' ability to identify healthier food options (Campos et al., 2011). Finally, as the definition suggests, the objective quality of a food is determined by the physical characteristics intrinsic to the food product (Product-oriented quality) and the characteristics of the production process including the environment in which a food is produced, processed and handled (Process-oriented quality) (Grunert et al., 1996).

1.4 Research objectives and hypotheses

The overall objective of this research is to evaluate whether extrinsic quality cues have desired effects from a scientific perspective on consumers' health-related quality perceptions and food choices. A better understanding of the role of information in the way consumers perceive the health-related quality of a food and make food choices is relevant for public health as it may contribute to the development of better nutrition and health communication.

Practically, this research will address the objective by means of two case studies. The first case study (Part II) covers the organic production as an extrinsic quality cue for vegetables. The main objective of this case study is to explore the gap between scientific evidence and consumer perception regarding the nutritional value and safety of organic compared to conventional vegetables. A second objective is to investigate the influence of consumers' health-related perception of organic on the consumption of vegetables. The second case study (Part III) deals with scientifically substantiated nutrition information on meals served in university canteens as the extrinsic quality cue. The main objective for this case study is to evaluate whether the nutrition information is used by canteen customers and assists them in making better informed and healthier food choices. Additionally, the second case study aims at identifying and understanding consumer preferences for alternative nutrition label formats for use in university canteens. The following research hypotheses emanate from these objectives based on the conceptual framework laid down in the previous section. Verification of these hypotheses will provide valuable insights in the role of various extrinsic quality cues in consumers' health-related quality perceptions and food choices.

Table 1.1 Research hypotheses

H1: Organic vegetables are healthier than conventional vegetables (Chapter 3).

- **H1a**: Organic vegetables are richer in beneficial nutrients than conventional vegetables.
- **H1b**: Organic vegetables contain less harmful contaminants than conventional vegetables.

H2: Consumers use the organic quality cue to assess the health-related quality (i.e. nutritional value and safety) of vegetables (Chapter 4).

H3: Consumers' perceived quality of organic vegetables does not match with objective health-related quality (Chapter 4).

H4: Perceived quality is a better determinant of food choice and dietary intake than objective quality (Chapter 5).

H5: Consumers use the nutrition information on canteen meals as an extrinsic quality cue to make healthier food choices leading to better dietary intakes (Chapter 6).

H6: Nutrition information that consumers perceive, like, understand and eventually use, leads to a better match between objective and perceived health-related quality (i.e. nutritional value) (Chapter 7).

H7: The influence of nutrition information on food choices and dietary intake differs between consumers according to personal characteristics, namely:

- **H7a**: their motivation to change diet and objective nutrition knowledge (Chapter 7).
- **H7b**: their diet-heath awareness, food choice motives, and socio-demographic characteristics (Chapter 6).

H8: Information characteristics and person-related factors influence consumer label preferences (Chapter 8).

- **H8a**: Label preferences vary according to consumers' preferences for simple, complete and non-coercive nutrition information.
- **H8b**: Label preferences vary according to consumers' ability and willingness to process the nutrition information as well as socio-demographic characteristics.

1.5 Research design and data sources

Data required to meet the research objectives and to test the research hypotheses are collected through quantitative research procedures. Figure 1.4 provides an overview of the nature of the data sources and the different research designs used in this doctoral research according to research field and case study considered. The data discussed in this dissertation originates from five studies that were executed independently from each other, including different samples of respondents, and on different points in time. A more detailed description of the different study samples and methodologies applied, are included in the methods section of the forthcoming chapters. The present section compares the methodology between these five studies or data collections in the order that the studies were conducted.

The case study on organic vegetables started with a thorough review of the literature available in 2009, from which nutrient and contaminant content data of organic and conventional vegetables were collected and compiled in detailed databases. The final database comprised of secondary data from 138 relevant data sources. From these sources, 1008 data points were from nutrients and 2572 from contaminants. Three classes of nutrients (i.e. vitamins and pro-vitamins, minerals and secondary plant metabolites) and three classes of contaminants (i.e. pesticide residues, heavy metals and nitrate) were considered in five vegetables (i.e. carrot, tomato, lettuce, spinach and potato).

In a second study, primary data on consumer perception of organic versus conventional vegetables were collected through a consumer survey in Flanders, Belgium, during the period of December 2006-February 2007 by means of self-administered structured questionnaires. A total sample of 529 respondents was obtained using a convenience sampling procedure.

For the assessment of the dietary intake of nutrients and contaminants in a third study, the vegetable composition data collected in Study 1 were combined with (1) secondary consumption data of vegetables for the Belgian population (n = 3245) and (2) primary consumption data of organic and conventional vegetables obtained from the consumer survey in Study 2 (valid n = 522).

The main study (Study 4) performed within the second case study on nutrition information in university canteens consisted of the development of a meal evaluation tool, and various consumer surveys before and after posting the nutrition information. The meal evaluation tool was developed based on existing meal recommendations, and food composition data and portion size estimates from secondary data sources. The nutrition-information intervention study used a one-group pretest-posttest design which means that each respondent was exposed to the intervention and served as his or her own control as assessed at baseline. A convenience sample of 224 students enrolled in the intervention, and completed the three-day food records and quantitative consumer surveys at baseline (October-November 2008) and follow-up (April-May 2009).

A final data collection (Study 5) was conducted through a structured, web-based consumer survey among students of Ghent University in February 2010. Preferences between alternative nutrition label formats for canteen meals were identified based on a discrete choice experiment (as the first part of the survey). In a second part of the survey, data on determinants of choice preferences were collected. In total, 1725 completed surveys were returned and judged suitable for further analyses.

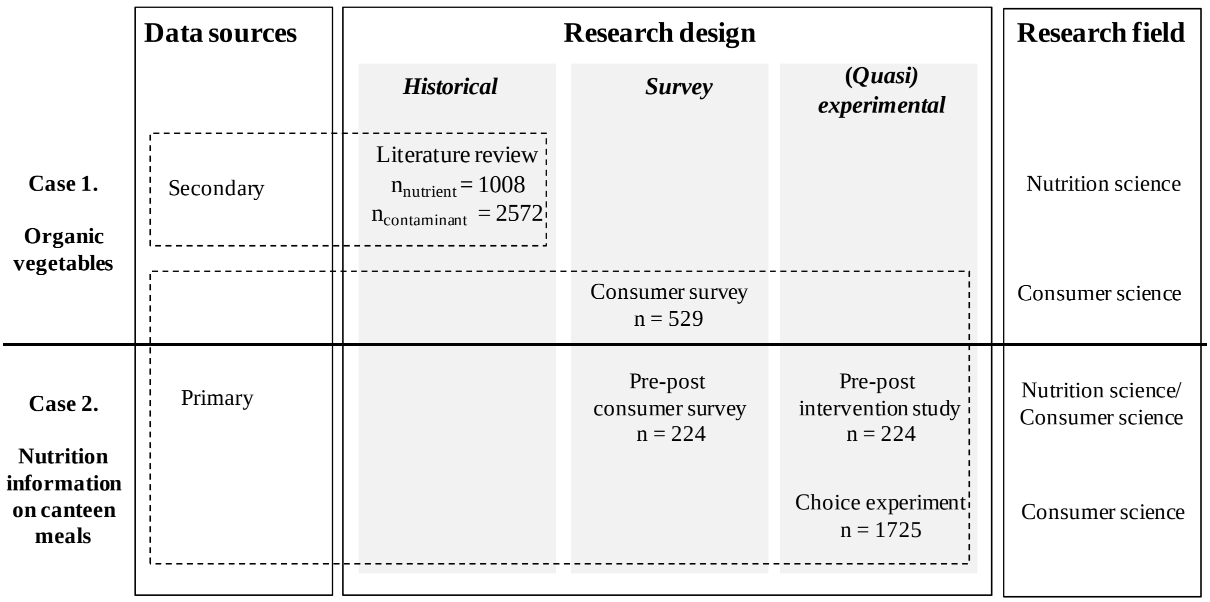

Figure 1.4 Research design and data sources

1.6 Thesis outline

This doctoral dissertation is a compilation of papers that have been published, accepted or submitted as contributions to international peer-reviewed journals, cross-covering the scientific disciplines of food science & technology, nutrition & dietetics, and agricultural economics & policy.

Part I provides next to an introductory chapter (*Chapter 1*), a research paper presenting insights into consumers' perceived importance of nutrients in food choices. This *Chapter 2* is not directly related to a specific research objective, but is incorporated in this introductory part to substantiate consumers' general interest in the nutritional value of foods when making food choices.

Part II compiles four research papers on the organic case study. *Chapter 3* describes the differences in nutritional value and safety between organic and conventional vegetables. For this purpose, detailed nutrient and contaminant content databases were developed based on secondary data sources. In *Chapter 4* consumers' perception related to the nutritional value and safety of organic vegetables is discussed. This chapter combines the evidence obtained in chapter 3 with the findings on consumer perception which were derived from primary data drawn from a consumer survey. *Chapter 5* describes the results of the effect of consuming organic versus conventional vegetables on consumers' nutrient and contaminant intakes. Therefore, the nutrient and contaminant content data collected in Chapter 3 were combined with secondary and primary vegetable consumption data obtained from the consumer survey in Chapter 4.

Part III covers the second case study on the effectiveness of nutrition information in university canteens. This part consists of three research papers. *Chapter 6* details the effect of a nutrition-information intervention in university canteens on consumers' meal choice and 24-hour nutrient intake. It also profiles consumer segments which were identified based on consumers' compliance with the recommended meal offer as indicated by the nutrition label. Primary data on pretest and posttest behaviour and related determinants were gathered by self-administered food records and consumer surveys. *Chapter 7* builds further on the intervention effect observed in Chapter 6 and contributes to the understanding of the causal pathway through which the intervention exerts its effect on determinants of meal choices in the total sample and for consumer subgroups. A hierarchy-of-effects model is conceptualised and validated by means of structural equation modelling. *Chapter 8* elaborates on the potential role of label format characteristics in the effectiveness of a nutrition-information intervention. Consumer preferences between alternative labels for use on canteen meals and their determinants are analysed using primary data from a stated choice modelling study.

Finally, **Part IV** provides the general discussion of the results obtained in the framework of the research objectives and hypotheses. Conclusions, implications, limitations and perspectives for further research are proposed.

Chapter 2

Consumers' perceived importance of nutrients in food choices

This chapter is based on:

Hoefkens, C., Verbeke, W., & Van Camp, J. (2011). European consumers' perceived importance of qualifying and disqualifying nutrients in food choices. *Food Quality and Preference*, *22*(6), 550-558.

Abstract

Providing nutrition information through food labels is increasingly important in helping consumers making better informed food choices. Major questions are whether consumers perceive specific nutrients as valuable in food choices, and whether their perception differs for qualifying and disqualifying nutrients. Consumers placing high importance on nutrition are expected to use nutrition labels more. This chapter reports on the perceived importance of nutrients, more specific of qualifying nutrients (fibre, vitamins/minerals) and disqualifying nutrients (energy, fat, saturated fat, salt, sugars), and possible differences between consumer groups. A pan-European consumer survey (n = 4828) was conducted with samples representative for age, gender and region in Belgium, France, Italy, Norway, Poland and Spain. Overall, consumers perceived the nutritional value of foods as important when selecting foods, and even more important for qualifying than for disqualifying nutrients. Statistically significant but small differences were observed between countries. A higher perceived importance was reported by women, older respondents, dieters and more health conscious respondents. The effects of children in the household, education and body mass index were very small. For age and gender compared to health consciousness, group differences were more significant regarding disqualifying nutrients than qualifying nutrients. Small effect sizes were found for dieting on the perceived importance of qualifying nutrients. Implications for nutrition policy makers and food industries are discussed.

2.1 Introduction

Consumers have become increasingly concerned and aware of the relationship between diet, food intake and health (International Food Information Council, 2000). The increased interest in nutrition and healthy eating has led consumers to become more interested in healthier food products (Grunert, 2006). The nutritional value of a food product cannot, however, be simply observed or experienced by a consumer even after the product is eaten (Caswell & Mojduszka, 1996). To appraise the nutritional contribution of foods to the overall diet in order to make informed food choices, consumers may use the nutrition information on food labels. Although consumers have shown a widespread interest in nutrition and nutrition labelling, other factors such as the taste and price have been competing priorities in relation to food (Drichoutis et al., 2005). Consumers may prefer the immediate benefits of a tasteful food product over the long-term benefits of a nutritious product (Verbeke, 2006). Although there is a lack of knowledge on how the interest in nutrition information varies according to different consumer groups, a cross-culturally consistent finding is that women, parents of children living at home, older consumers and consumers in North/Central Europe relative to South Europe tend to be more interested in nutrition information (EC Directorate General for Health and Consumer Protection, 2005; European Heart Network, 2007; Grunert & Wills, 2007). There are also indications that the situation and the type of food product influence the degree of interest. For example, a higher interest is observed for nutrition information related to processed products with a low degree of transparency and in situations with low time constraints or where the product is bought for the first time. Also the type of nutrition information determines the level of interest. The nutrients for which prime interest has been reported are fat, energy, salt and sugar, which are all so-called disqualifying nutrients (Grunert & Wills, 2007). Other nutrients mentioned by the participants of the BEUC survey (BEUC, 2005) were vitamins, cholesterol, carbohydrates, minerals, protein, fibre, saturated and unsaturated fatty acids. A disqualifying nutrient, as opposed to a qualifying nutrient, is a nutrient that, when present in a food in too high amounts, potentially disqualifies the food for bearing a nutrition and/or health claim (Tetens et al., 2007). Strictly, energy is not a nutrient, but for the purpose of this study energy was considered as one the disqualifying nutrients in line with Tetens et al. (2007). Because calories compared to energy are the best established notion with European consumers, the term “calories” was used in this consumer study (Cowburn & Stockley, 2005; van Kleef et al., 2008).

Several reasons could explain why consumers react differently to negative nutrition attributes versus positive ones. Attribute framing theory suggests that individuals may have more favourable evaluations of attributes (e.g. nutrients) when described positively than when described negatively (Levin et al., 1998). Following the prospect theory of Kahneman and Tversky (1979), consumers may attach more importance to attributes associated with potential losses than attributes involving potential gains (Baltas, 2001). Moreover, consumers may believe that dietary supplements can easily solve nutrient deficiencies, but to reduce the intake of disqualifying nutrients a drastic change in diet and physical activity is often necessary which may be considered far more difficult (Russo et al., 1986). Another reason could be the introduction of simplified front-of-pack (FOP) labels and nutrient profiles which emphasise disqualifying nutrients. Although from a regulatory point of view nutrient profiling is not advancing as quickly as originally planned within the EU, nutrient profiling systems categorising foods based on their food composition, have been developed for purposes such as to regulate nutrition and health claims, to assist consumers in making healthier food choices and to stimulate food reformulation and innovation (EC Regulation 1924/2006). FOP nutrition labelling is also a recent development resulting from calls for at-a-glance information to help consumers select healthier food products more easily. The FOP labels have been introduced voluntarily as a complementary scheme to the regulated back-of-pack nutrition table (EC Regulation 90/496), and nutrition and health claims. Examples are the guideline daily amounts (GDA) and traffic light label which include information on fat, saturated fat, sugar and salt (sodium). The focus on disqualifying nutrients is in line with consumers' main use of nutrition labels, namely to avoid the negative nutrients in food products (Drichoutis et al., 2006). However, some studies have argued that a positive approach to encourage consumers to a more healthy dietary pattern would be more effective (Miller et al., 2009; Nicklas, 2009). They suggest the use of a nutrient density profiling system promoting foods providing substantial amounts of nutrients, i.e. nutrient-dense foods, instead of energy-dense foods. This discourse about targeting consumers with positive versus negative information, or providing consumers with qualifying versus disqualifying nutrient information was a major rationale for the present chapter.

The basic assumption from which the study departed was that without a basic interest in nutrients, the probability of using and understanding (specific) nutrition information on food labels is less likely. While there is a growing body of literature on the use and understanding of nutrition labels (reviewed by Cowburn & Stockley (2005) and Grunert & Wills (2007), to the authors' knowledge only one study examined food label use in relation to the belief that nutrition is important in making food choices which is a preceding step in the decision-making process. This study revealed that more label users believed that nutrition information is important in making food choices than label non-users (Smith et al., 2000). The lack of information on the perceived importance of individual nutrients, and qualifying versus disqualifying nutrients, in food choices raised two questions. First, do European consumers find specific nutrients important in selecting foods? Second, do consumers perceive disqualifying nutrients differently in terms of importance in food choices than qualifying nutrients? Since heterogeneity of interests and needs across consumers is expected, the objective of this chapter is to describe the perceived importance of (qualifying versus disqualifying) nutrients and differences in perceived nutrient importance between consumer groups with different socio-cultural backgrounds. Socio-demographic characteristics (e.g. gender and age), behavioural characteristics (such as special diet status), body mass index (BMI) and health consciousness were used to profile consumer groups. Results from this chapter are valuable to food manufacturers and retailers, governmental and non-governmental organisations to know which nutrition information to provide on food labels to which audience in order to increase their potential use and impact on food choices.

2.2 Methodology

2.2.1 Study design and population

Pan-European data were collected through a cross-sectional quantitative survey with samples representative for age, gender and region in six European countries: Belgium (n = 826), France (n = 801), Italy (n = 800), Norway (n = 798), Poland (n = 803) and Spain (n = 800). These countries have been selected in order to cover the geographical North-South and East-West axes of Europe. Data collection was conducted during Fall 2007. A total of 4828 participants between the ages of 20 and 70 years were randomly selected, stratifying for age and region, from the representative TNS European Online Access Panel (Malhotra & Peterson, 2006). All procedures for contact and questionnaire administration were electronic.

The socio-demographic profile of the national and pooled samples is presented in Table 2.1. Both genders were equally represented as the population was intentionally not restricted to the main responsible for food purchasing. Age distributions, mean age and household sizes matched closely with the national census data of the respective countries. About half of the sample (52.6%) had higher education (university college or university), 38.8% upper secondary and 8.6% lower secondary education. The overrepresentation of higher educated respondents, in particular in Poland and Spain, is attributed to the use of a web-based data collection method.

2.2.2 Questionnaire

Participants were asked to complete a self-administered structured electronic questionnaire. The questionnaire consisted of several sections dealing with (1) behavioural and attitudinal items relating to food purchasing in general, (2) attitudes towards traditional foods in particular, and (3) personal data relating to lifestyle, general interests and socio-demographics. The selection of items was informed by qualitative exploratory research in the same set of countries (Guerrero et al., 2010; Guerrero et al., 2009). The master questionnaire was developed in English and translated into the national languages using back-translation to ensure linguistic equivalence (Brislin, 1970; Maneesriwongul & Dixon, 2004). Before starting with the fieldwork, the questionnaire was extensively pretested through personal interviews with 15-20 respondents in each country. The overall questionnaire content and data collection details have been extensively described in Pieniak et al. (2009) and Vanhonacker et al. (2010). The analyses reported in this chapter focus on items that were included in the first and third section of the overall questionnaire.

Table 2.1 Sample characteristics (%, n = 4828)

	Pooled sample (n = 4828)	Belgium (n = 826)	France (n = 801)	Italy (n = 800)	Norway (n = 798)	Poland (n = 803)	Spain (n = 800)
Gender							
Male	50.8	50.6	48.1	52.8	50.9	49.8	52.6
Female	49.2	49.4	51.9	47.3	49.1	50.2	47.4
Age							
< 25 years	12.7	11.6	14.4	12.4	11.5	14.9	11.6
26 to 35 years	24.2	18.8	21.1	26.3	26.6	25.2	27.4
36 to 45 years	23.5	23.2	24.5	24.3	24.4	18.7	26.1
46 to 55 years	22.0	23.1	21.7	19.8	20.3	27.0	19.9
> 55 years	17.6	23.2	18.4	17.4	17.2	14.2	15.0
Education							
Lower secondary	8.6	8.1	9.0	12.4	9.8	2.6	9.4
Upper secondary	38.8	35.2	37.5	61.4	47.9	26.7	24.4
Higher	52.6	56.6	53.5	26.2	42.3	70.7	66.2
Children in the household							
Yes	36.6	34.6	37.6	31.5	41.9	37.6	36.4
No	63.4	65.4	62.4	68.5	58.1	62.4	63.6

2.2.3 Measurement and scaling

Consumers' perceived importance of nutrients when making food choices was measured using a 7-point Likert scale associated with the statement "It is important to me that the food I eat on a typical weekday is …": "Low in calories", "Low in fat", "Low in saturated fat", "Low in sugar", "Low in salt", "High in dietary fibre" and "High in vitamins and minerals". The anchor points of the scale were defined as "Totally disagree" (= 1), "Neither agree nor disagree" (= 4) and "Totally agree" (= 7). The selection of energy, fat, saturated fat, sugar and salt as disqualifying nutrients was informed by the recent developments in nutrition labelling and the ongoing debate on GDA versus TL food labelling for which these disqualifying nutrients form the core. The last two nutrients, dietary fibre and vitamins/minerals or qualifying nutrients were selected due their relevance from a nutrition and health claims point of view. The recorded importance scores were used as dependent variables in the analyses.

Explanatory variables included socio-demographics such as country of residence (categorical), gender (categorical), age (continuous), presence of children in the household (categorical) and education level (lower secondary, higher secondary, higher) (categorical). Additional explanatory background attitudes and variables included health consciousness, nutritional status (expressed as BMI) and dieting. Health consciousness was measured using three items from the Food Choice Questionnaire (Steptoe et al., 1995): "I consider myself as very health conscious", "Health is very important to me", "I am as healthy as anyone I know at my age" on 7-point Likert scales ranging from "Totally disagree" (= 1) to "Totally agree" (= 7). Nutritional status was calculated based on self-reported measures of weight and height. Dieting was measured as a categorical variable (yes/no) for "Low salt diet", "Low sugar diet", "Low calories diet", "Low fat diet".

2.2.4 Statistical analyses

Statistical analyses were performed using the statistical software program SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $\alpha = 0.05$. Pair-wise deletion was used as the method for treating missing values as sample sizes were large and the number of missing responses very low.

Descriptive analyses were used to describe the dependent variables. Differences depending on personal characteristics were analysed through independent samples t-tests and one-way ANOVA F-tests (with partial eta-squared statistics). Regression analysis by analysis of covariance (ANCOVA) was performed to simultaneously investigate the effects of explanatory variables on consumers' perceived importance of qualifying and disqualifying nutrients in daily food purchasing. Effect sizes, or partial eta-squared (η^2), were expressed as the proportion of variance in the dependent variable (i.e. perceived importance of nutrients in food choices) explained by an independent variable (i.e. socio-demographic or behavioural characteristic). Effect size estimations indicate the strength of a relationship between variables and the significance of differences between groups (Levine & Hullett, 2002). Effect sizes are considered small between 0.01 and 0.06, medium from 0.06 and large when equal to or greater than 0.13 (Harlow, 2005). This measure was included in the analysis to have a better interpretation of the p-value for which very low values can be obtained from large samples sizes as in this study. SPSS's General Linear Factorial Model (GLM) was used to conduct the ANCOVA model and to test its statistical assumptions (multicollinearity, equality of error variances, normally distributed residual terms, independence of covariate and factor, and homogeneity of regression slope). Group differences were found on the covariate health consciousness for country of residence and dieting, but the use of random sampling assures that these differences occurred by chance making ANCOVA appropriate (Miller & Chapman, 2001).

2.3 Results

2.3.1 Perceived importance of qualifying and disqualifying nutrients in food choices

The results of consumers' perceived importance of nutrients in general, and specific qualifying and disqualifying nutrients in particular are presented in Table 2.2. The mean importance scores on all nutrients were around five on a 7-point Likert scale and differed significantly between the group of qualifying ($\mu = 5.2$) and disqualifying ($\mu = 4.9$) nutrients. This indicates that, in general, consumers perceived the nutritional value of foods as important when selecting foods, and even more important for qualifying nutrients than for disqualifying nutrients. When comparing the different nutrients, a relative higher mean importance score was observed for vitamins and minerals ($\mu = 5.6$), and saturated fat ($\mu = 5.2$). A relatively lower importance was attached to energy ($\mu = 4.6$) and fibre ($\mu = 4.7$).

In order to explore the effect of socio-demographic and behavioural characteristics on the perceived importance of qualifying nutrients on the one hand and disqualifying nutrients on the other hand, an average of the importance scores of the individual qualifying and disqualifying nutrients, respectively, was calculated. The Cronbach's alpha coefficient for the disqualifying nutrient construct was 0.88, while for the qualifying nutrient construct the Cronbach's alpha coefficient amounted to 0.70, both denoting good and acceptable internal consistency reliability (Nunnally, 1978). These composite constructs were used as dependent variable in the GLM ANCOVA model.

Table 2.2 Consumers' perceived importance of nutrients in food choices, frequency distribution (%), mean scores and standard deviations (SD) on 7-point Likert scale[1] (n = 4828)

Perceived importance of…	Totally disagree/disagree	Slightly disagree	Neutral	Slightly agree	Agree/ totally agree	Mean (SD)
Nutrients in general	4	5	24	33	34	5.0^{f} (1.2)
Disqualifying nutrients	4	6	27	30	33	4.9^{d} (1.3)
Calories	9	8	33	22	27	4.6^{a} (1.5)
Fat	7	7	24	23	38	4.9^{e} (1.5)
Saturated fat	6	5	24	19	46	5.2^{g} (1.5)
Sugar	6	7	28	22	38	$5.0^{f,e}$ (1.5)
Salt	7	7	31	20	34	4.8^{c} (1.5)
Qualifying nutrients	3	4	15	27	51	5.2^{g} (1.3)
Fibre	7	6	32	25	29	4.7^{b} (1.5)
Vitamins and minerals	4	2	14	21	60	5.6^{h} (1.4)

[1] Categories "totally disagree" and "disagree", and "agree" and "totally agree", from the initial 7-point scale were merged for clarity of presentation; means (SD) and statistical analyses as reported in the text were performed with the original 7-point scale data

[a-g] indicate significantly different means using ANOVA F-tests with Hochberg's GT2 post hoc test on a 7-point scale (1 = totally disagree; 7 = totally agree)

2.3.2 Impact of socio-demographic characteristics

The main results of the differences in perceived importance of disqualifying and qualifying nutrients according to selected socio-demographic characteristics are reported in Table 2.3. Gender differences were found for each of the selected nutrients with females consistently reporting higher mean importance scores compared to males (all $p < 0.001$). Moreover, the difference in importance between males and females was larger for disqualifying nutrients ($\eta^2 = 0.046$) compared to qualifying nutrients ($\eta^2 = 0.029$) when selecting foods. The partial eta-squared values for age showed that the differences between the perceived importance of each of the nutrients and the different age groups were small to moderate (all $p < 0.001$, $\eta^2 \leq 0.06$), with an increasing perceived importance with higher age. Also for age the group differences were larger regarding disqualifying nutrients ($\eta^2 = 0.053$) than qualifying nutrients ($\eta^2 = 0.043$). With regard to the educational level, differences in importance were observed for all disqualifying nutrients (all $p < 0.05$), except salt ($p = 0.382$), but not for the selected qualifying nutrients. Nevertheless, the effect sizes of education on the perceived importance of disqualifying nutrients were very small ($\eta^2 < 0.01$). Also the presence of children in the household was found to have only very small effects on the perceived importance of both qualifying and disqualifying nutrients ($\eta^2 < 0.01$). The country of residence had a larger effect on the perceived importance of qualifying nutrients ($\eta^2 = 0.033$) than disqualifying nutrients ($\eta^2 = 0.011$), especially on vitamins and minerals ($\eta^2 = 0.041$). The lowest mean importance scores were consistently found for the qualifying and disqualifying nutrients among the Norwegian consumers. Spain or Poland had, depending on the nutrient, the highest mean importance scores. For all socio-demographic groups the mean importance score of qualifying nutrients was significantly higher than the mean importance score of disqualifying nutrients (all paired $p < 0.001$). For example, men as well as women attached significantly higher importance to qualifying nutrients compared to disqualifying nutrients.

From these findings, it is apparent that gender, age and the country of residence explained to a relatively important extent differences in the perceived importance of nutrients in food choices compared to education and the presence of children in the household. Therefore, the first three variables were included in the ANCOVA models as socio-demographic explanatory variables for the prediction of the perceived importance of disqualifying (Model 1) and qualifying nutrients (Model 2).

2.3.3 Impact of behavioural characteristics

The main results of the differences in perceived importance of disqualifying and qualifying nutrients according to selected behavioural characteristics are reported in Table 2.4. Again, each subgroup had a significantly higher mean importance score for qualifying nutrients compared to disqualifying nutrient (all paired $p < 0.001$), except the group of consumers on a specific diet for whom the difference between the mean importance scores was not significant. As could be expected, consumers on a diet low in energy, low in fat, low in sugar and/or low in salt attached a significantly higher importance to a low content of energy ($\eta^2 = 0.047$), fat ($\eta^2 = 0.048$), sugar ($\eta^2 = 0.045$) and/or salt ($\eta^2 = 0.047$), respectively, compared to consumers not on a diet. For each of the selected nutrients, both qualifying and disqualifying, consumers on a diet consistently reported higher mean importance scores than consumers not on a diet (all $p < 0.001$). However, rather small effect sizes were found for dieting on the perceived importance of qualifying nutrients, ranging from 0.008 for being on a low sugar and/or salt diet to 0.037 for being on diet in general. No significant impact of the BMI on consumers' perceived importance of the nutritional value of foods was observed ($\eta^2 < 0.01$).

Table 2.3 Socio-demographic differences in consumers' perceived importance of nutrients in food choices (n = 4828)

		Perceived importance of …									
		Nutrients in general	**Disqualifying nutrients**	Calories	Fat	Saturated fat	Sugar	Salt	**Qualifying nutrients**	Fibre	Vitamins and minerals
Gender	Male	4.72^{x}	4.62^{x}	4.27^{x}	4.64^{x}	4.92^{x}	4.68^{x}	4.59^{x}	4.96^{x}	4.51^{x}	5.41^{x}
	Female	5.23^{y}	5.16^{y}	4.89^{y}	5.24^{y}	5.41^{y}	5.23^{y}	5.05^{y}	5.39^{y}	4.96^{y}	5.83^{y}
	t-value (p-value)	-15.16 (< 0.001)	-15.22 (< 0.001)	-14.39 (< 0.001)	-13.59 (< 0.001)	-11.06 (< 0.001)	-12.78 (< 0.001)	-10.43 (< 0.001)	-12.06 (< 0.001)	-10.69 (< 0.001)	-10.45 (< 0.001)
	Partial eta-squared	0.046	0.046	0.042	0.038	0.025	0.033	0.022	0.029	0.023	0.022
Age	< 25 years	4.54^{a}	4.44^{a}	4.23^{a}	4.53^{a}	4.67^{a}	4.46^{a}	4.28^{a}	4.78^{a}	4.32^{a}	5.24^{a}
	26 to 35 years	4.72^{b}	4.64^{b}	4.38^{a,b}	4.72^{a}	4.83^{a}	4.71^{b}	4.56^{b}	4.93^{a}	4.45^{a}	5.43^{a,b}
	36 to 45 years	4.93^{c}	4.85^{c}	4.51^{b}	4.93^{b}	5.14^{b}	4.91^{c}	4.74^{c}	5.14^{b}	4.71^{b}	5.59^{b}
	46 to 55 years	5.24^{d}	5.16^{d}	4.81^{c}	5.16^{c}	5.49^{c}	5.25^{d}	5.13^{d}	5.45^{c}	5.03^{c}	5.88^{c}
	> 55 years	5.33^{d}	5.26^{d}	4.87^{c}	5.26^{c}	5.58^{c}	5.32^{d}	5.28^{d}	5.49^{c}	5.09^{c}	5.88^{c}
	F-value (p-value)	70.73 (< 0.001)	67.92 (< 0.001)^{w}	27.65 (< 0.001)^{w}	31.53 (< 0.001)^{w}	59.07 (< 0.001)	48.18 (< 0.001)^{w}	59.39 (< 0.001)^{w}	54.43 (< 0.001)	49.38 (< 0.001)	33.58 (< 0.001)^{w}
	Partial eta-squared	0.055	0.053	0.023	0.026	0.048	0.039	0.048	0.043	0.040	0.028
Country of residence	Belgian	5.04^{b}	4.94^{b,c}	4.68^{c,d}	5.06^{b}	5.14^{b}	4.95^{a,b}	4.86^{a,c}	5.28^{b}	4.84^{c}	5.73^{b}
	French	4.94^{b}	4.83^{b}	4.43^{b}	4.90^{b}	5.20^{b,c}	4.88^{a}	4.72^{a,b}	5.21^{b}	4.75^{b,c}	5.68^{b}
	Italian	5.04^{b}	4.96^{b,c}	4.79^{d}	5.01^{b}	5.36^{c}	4.88^{a}	4.76^{a,b}	5.22^{b}	4.82^{b,c}	5.63^{b}
	Norwegian	4.65^{a}	4.61^{a}	4.35^{b}	4.53^{a}	4.69^{a}	4.84^{a}	4.66^{a}	4.73^{a}	4.40^{a}	5.05^{a}
	Polish	5.11^{b}	4.96^{b,c}	4.52^{c,b}	5.00^{b}	5.20^{b,c}	5.12^{b}	5.03^{c}	5.48^{c}	4.96^{c}	5.99^{c}
	Spanish	5.04^{b}	5.01^{c}	4.66^{c,d}	5.10^{b}	5.37^{c}	5.04^{a,b}	4.89^{b,c}	5.13^{b}	4.63^{b}	5.63^{b}
	F-value (p-value)	16.06 (< 0.001)^{w}	11.40 (< 0.001)^{w}	10.37 (< 0.001)^{w}	14.59 (< 0.001)^{w}	20.93 (< 0.001)^{w}	3.60 (< 0.001)^{w}	5.43 (< 0.001)^{w}	30.87 (< 0.001)^{w}	14.17 (< 0.001)^{w}	38.68 (< 0.001)^{w}
	Partial eta-squared	0.016	0.011	0.010	0.015	0.022	0.004	0.006	0.033	0.015	0.041

$^{a, b, c, d}$ indicate significantly different means using ANOVA F-tests with Hochberg's GT2 post hoc test (when equal variances not assumed: Welch test (w) with Dunnett's C post hoc test) on a 7-point scale (1 = totally disagree; 7 = totally agree)

$^{x, y}$ indicate significantly different means using independent samples t-tests on a 7-point scale (1 = totally disagree; 7 = totally agree)

Table 2.4 Differences in consumers' perceived importance of nutrients in food choices according to behavioural characteristics and health consciousness (n = 4828)

			Perceived importance of …									
			Nutrients in general	**Disqualifying nutrients**	Calories	Fat	Saturated fat	Sugar	Salt	**Qualifying nutrients**	Fibre	Vitamins and minerals
Special diet status												
Low calorie diet	Yes		5.65^{y}	5.65^{y}	5.58^{y}	5.74^{y}	5.84^{y}	5.67^{y}	5.47^{y}	5.64^{y}	5.32^{y}	5.95^{y}
	No		4.90^{x}	4.81^{x}	4.46^{x}	4.85^{x}	5.09^{x}	4.88^{x}	4.75^{x}	5.13^{x}	4.67^{x}	5.58^{x}
		t-value (p-value)	-13.24 (< 0.001)	-14.19 (< 0.001)	-15.35 (< 0.001)	-11.80 (< 0.001)	-10.06 (< 0.001)	-10.87 (< 0.001)	-9.69 (< 0.001)	-8.44 (< 0.001)	-8.50 (< 0.001)	-5.28 (< 0.001)
		Partial eta-squared	0.035	0.040	0.047	0.029	0.021	0.024	0.019	0.015	0.017	0.006
Low fat diet	Yes		5.64^{y}	5.64^{y}	5.35^{y}	5.79^{y}	5.92^{y}	5.65^{y}	5.50^{y}	5.65^{y}	5.31^{y}	5.97^{y}
	No		4.86^{x}	4.77^{x}	4.45^{x}	4.80^{x}	5.04^{x}	4.84^{x}	4.71^{x}	5.10^{x}	4.64^{x}	5.56^{x}
		t-value (p-value)	-16.05 (< 0.001)	-17.03 (< 0.001)	-14.19 (< 0.001)	-15.80 (< 0.001)	-14.64 (< 0.001)	-12.90 (< 0.001)	-11.99 (< 0.001)	-10.47 (< 0.001)	-11.04 (< 0.001)	-6.97 (< 0.001)
		Partial eta-squared	0.051	0.057	0.041	0.048	0.038	0.034	0.031	0.022	0.025	0.010
Low sugar diet	Yes		5.65^{y}	5.63^{y}	5.28^{y}	5.54^{y}	5.85^{y}	5.94^{y}	5.58^{y}	5.54^{y}	5.31^{y}	6.04^{y}
	No		4.90^{x}	4.81^{x}	4.50^{x}	4.87^{x}	5.09^{x}	4.85^{x}	4.74^{x}	5.14^{x}	4.68^{x}	5.58^{x}
		t-value (p-value)	-12.84 (< 0.001)	-13.40 (< 0.001)	-9.84 (< 0.001)	-8.63 (< 0.001)	-10.19 (< 0.001)	14.83 (< 0.001)	-11.01 (< 0.001)	-6.15 (< 0.001)	-8.73 (< 0.001)	-7.30 (< 0.001)
		Partial eta-squared	0.033	0.036	0.022	0.016	0.020	0.045	0.025	0.008	0.016	0.009
Low salt diet	Yes		5.57^{y}	5.57^{y}	5.14^{y}	5.54^{y}	5.79^{y}	5.50^{y}	5.93^{y}	5.54^{y}	5.19^{y}	5.89^{y}
	No		4.92^{x}	4.83^{x}	4.52^{x}	4.88^{x}	5.10^{x}	4.90^{x}	4.72^{x}	5.14^{x}	4.69^{x}	5.59^{x}
		t-value (p-value)	-10.61 (< 0.001)	-11.59 (< 0.001)	-7.80 (< 0.001)	-8.12 (< 0.001)	-8.45 (< 0.001)	-7.07 (< 0.001)	-15.82 (< 0.001)	-6.15 (< 0.001)	-6.56 (< 0.001)	-4.04 (< 0.001)
		Partial eta-squared	0.023	0.027	0.013	0.014	0.015	0.012	0.047	0.008	0.009	0.003
Diet in general	Yes		5.42^{y}	5.38^{y}	5.06^{y}	5.43^{y}	5.63^{y}	5.46^{y}	5.31^{y}	5.54^{y}	5.15^{y}	5.91^{y}
	No		4.77^{x}	4.67^{x}	4.36^{x}	4.72^{x}	4.95^{x}	4.73^{x}	4.60^{x}	5.01^{x}	4.55^{x}	5.49^{x}
		t-value (p-value)	-17.78 (< 0.001)	-18.37 (< 0.001)	-14.52 (< 0.001)	-14.45 (< 0.001)	-14.16 (< 0.001)	-15.60 (< 0.001)	-14.69 (< 0.001)	-13.55 (< 0.001)	-13.15 (< 0.001)	-9.78 (< 0.001)
		Partial eta-squared	0.064	0.068	0.046	0.045	0.041	0.051	0.046	0.037	0.037	0.020
Health consciousness	Not health conscious		3.93^{a}	3.86^{a}	3.67^{a}	3.94^{a}	3.99^{a}	3.90^{a}	3.76^{a}	4.11^{a}	3.76^{a}	4.46^{a}
	Health conscious		4.94^{b}	4.86^{b}	4.56^{b}	4.89^{b}	5.16^{b}	4.91^{b}	4.79^{b}	5.14^{b}	4.68^{b}	5.60^{b}
	Very health conscious		5.34^{c}	5.25^{c}	4.88^{c}	5.31^{c}	5.55^{c}	5.34^{c}	5.20^{c}	5.56^{c}	5.11^{c}	6.02^{c}
		F-value (p-value)	436 (< 0.001)^{w}	374 (< 0.001)^{w}	172 (< 0.001)^{w}	230 (< 0.001)^{w}	296 (< 0.001)^{w}	254 (< 0.001)^{w}	271 (< 0.001)^{w}	390 (< 0.001)^{w}	240 (< 0.001)^{w}	359 (< 0.001)
		Partial eta-squared	0.150	0.131	0.067	0.083	0.108	0.097	0.093	0.140	0.091	0.132

[a, b, c, d] indicate significantly different means using ANOVA F-tests with Hochberg's GT2 post hoc test (when equal variances not assumed: Welch test (w) with Dunnett's C post hoc test) on a 7-point scale (1 = totally disagree; 7 = totally agree)

[x, y] indicate significantly different means using independent samples t-tests on a 7-point scale (1 = totally disagree; 7 = totally agree)

Consumers who were more health conscious perceived each of the nutrients as significantly more important than less health conscious consumers (all $p < 0.001$, $\eta^2 > 0.06$). Although significant, a small difference was observed between the importance attached to qualifying nutrients and disqualifying nutrients according to the degree of health consciousness (all paired $p < 0.001$). The lowest partial eta-squared value was found for the relation between the level of health consciousness and the perceived importance of low energy ($\eta^2 = 0.067$), while the highest value was obtained for the importance of vitamins and minerals ($\eta^2 = 0.132$). Based on the effect sizes for the different behavioural characteristics on the perceived importance of qualifying and disqualifying nutrients, consumers' special diet status and health consciousness were included in the ANCOVA models while BMI was excluded from the analysis.

2.3.4 ANCOVA regression

The ANCOVA results are summarised in Table 2.5. To simplify the presentation, only the F-statistics for the main effects and statistically significant interactions are shown. The first ANCOVA model identified factors that may influence consumers' perceived importance of disqualifying nutrients when choosing foods, while the second model considered the factors affecting the importance attached to qualifying nutrients. Both models explained about 30% of the variance of the dependent variable. Results across the models confirmed that age, gender, country of residence, diet status and health consciousness all influenced consumers' perceived importance. Women ($p = 0.034$) and consumers on a diet ($p < 0.001$) attached significantly more importance to disqualifying nutrients in food choices. The parameter estimates indicating the effect of each country on the perceived importance of disqualifying nutrients, showed that given five consumers with similar age and health consciousness, the Polish consumer attached a significantly lower importance than the Belgian, Norwegian, French and Italian consumer (all $p < 0.05$). Nevertheless, the difference was very small with η^2 below 0.01. Furthermore, perceived importance of disqualifying nutrients increased with increasing age and level of health consciousness (both $p < 0.001$). Similar results were found for age, health consciousness and the perceived importance of qualifying nutrients (both $p < 0.001$). Although a similar trend was observed between the perceived importance of qualifying nutrients and gender on the one hand and diet status on the other hand, the results were not significant when consulting the between-groups effects (or contrasts) (both $p > 0.05$). With regard to the country effect on the perceived importance of qualifying nutrients, Spanish consumers seemed to attach less importance than Norwegian and French consumers (both $p < 0.05$). Also Italian consumers perceived qualifying nutrients less important than French consumers when selecting foods ($p = 0.031$). However, the differences were again small ($\eta^2 < 0.01$). From the partial eta-squared values, it was observed that the relative importance and the effect size of the different explanatory variables were different between the two models. In the model of perceived importance of disqualifying nutrients, the order of relevance was: level of health consciousness ($\eta^2 = 0.151$), age ($\eta^2 = 0.025$), gender ($\eta^2 = 0.024$), diet status ($\eta^2 = 0.020$) and country of residence ($\eta^2 = 0.004$). The order of explanatory variables for the model of perceived importance of qualifying nutrients was: health consciousness ($\eta^2 = 0.158$), age ($\eta^2 = 0.018$), gender ($\eta^2 = 0.017$), country of residence ($\eta^2 = 0.009$) and diet status ($\eta^2 = 0.002$). Finally, significant interactions were found between country and diet for model 1 and between gender, country and diet for model 2. However, the respective partial eta-squared values were very small, indicating very small effects on the dependent variables.

The model with perceived importance of nutrients in general as dependent variable did not yield additional insights over those obtained for models 1 and 2. Therefore, findings for model 3 are not presented.

Table 2.5 Analysis of covariance results for consumers' perceived importance of disqualifying and qualifying nutrients, and nutrients in general

		Model 1: Disqualifying nutrients				Model 2: Qualifying nutrients			
		df	F	p-value	η^2	df	F	p-value	η^2
Main effects	Gender	1	120.305	< 0.001	0.024	1	81.867	< 0.001	0.017
	Country of residence	5	4.130	0.001	0.004	5	8.435	< 0.001	0.009
	Diet in general	1	98.612	< 0.001	0.020	1	9.900	0.002	0.002
Two-way interaction	Country x Diet	5	3.124	0.008	0.003	5	0.201	0.962	< 0.001
Three-way interaction	Gender x Country x Diet	5	0.508	0.770	0.001	5	2.501	0.029	0.003
Covariates	Age	1	124.208	< 0.001	0.025	1	87.890	< 0.001	0.018
	Health consciousness	1	856.280	< 0.001	0.151	1	901.464	< 0.001	0.158

Note: Interactions Gender x Diet, Gender x Country were not significant

2.4 Discussion and conclusions

The present chapter described to what extent consumers found specific nutrients important in making food choices and whether the degree of importance differed between disqualifying and qualifying nutrients. The chapter provides insights into differences in perceived importance of nutrients between consumers groups with different socio-cultural backgrounds.

In general, consumers attached a high importance to the nutritional value of foods in food choices. The level of importance was higher for qualifying than for disqualifying nutrients. This finding does not fit the prospect theory of Kahneman and Tversky (1979) from which one can expect a stronger interest in avoiding potential losses in personal health from eating too much energy, fat, saturated fat, sugar and salt than in potential gains from eating dietary fibre and especially vitamins/minerals in this case. A first possible explanation may be that consumers are becoming more and more aware of the concept of energy balance meaning that their energy expenditure through physical activity may regulate their energy accumulation in the body after food intake. A second possible explanation is that excessive disqualifying nutrients are not associated with potential losses in consumers' minds. A third explanation could relate to attribute framing theory, expecting more favourable evaluations of attributes (e.g. nutrients) when described positively than when described negatively (Levin et al., 1998). Further research is recommended to shed more light on which explanations hold in this specific context of qualifying versus disqualifying nutrients.

Previous studies consistently found a higher interest in nutrition information by women, parents of children living at home, older consumers and consumers in North/Central Europe (EC Directorate General for Health and Consumer Protection, 2005; European Heart Network, 2007; Grunert & Wills, 2007). In our study the same gender and age effects were observed for the perceived importance of nutrients in food choices. The geographical/cultural effect as well as the effect of children in the household could not be confirmed in this study. Only small though statistically significant differences in the perceived importance of nutrients between households with and without children and between countries were detected. The gender differences might reflect the generally accepted stronger health consciousness of women (Duvigneaud et al., 2007). However, after controlling for the level of health consciousness, the gender effect remained significant. Additionally, differences in perceived nutrient importance according to the level of health consciousness were in line with the study of Petrovici and Ritson (2006) confirming the association between the levels of health consciousness and nutrition information search. Next to gender, also education was reported by Drichoutis et al. (2006) to be positively associated with the use of nutrition labels. A similar relation could not be identified in the present study as the educational level only marginally affected consumers‘ perceived importance of both qualifying and disqualifying nutrients. The nutritional status expressed as BMI was also found to have only a small effect on the importance attached to nutrients. Previous study results are mixed regarding the relation between BMI and label use. For example, Satia et al. (2005) and Lewis et al. (2009) reported a positive relationship between being obese and overweight, respectively, and using nutrition label information, while the studies by Neuhouser et al. (1999) and Krukowski et al. (2006) did not obtain a significant association. The findings with respect to the effect of a special diet status on consumers' perceived importance corroborate with Drichoutis et al. (2006) and confirm that dieters are more concerned about nutrition and health and, consequently, are more likely to use nutrition labels.

Some limitations of this study should be acknowledged. First, this study used socio-demographic characteristics, special diet status, BMI and the level of health consciousness to profile consumer groups with a differing perceived importance of qualifying and disqualifying nutrients. Some differences in interest among consumers cannot, however, be attributed to these variables. Further research investigating the effect of a broader range of factors such as background attitudes and knowledge, product-related factors (e.g. price), information variables (e.g. source, format), environmental factors (e.g. situation), social factors (e.g. illness in social environment), emotional aspects (e.g. mood), together with those considered in this study is recommended. It should also be noted that most consumers do not only consider foods as a source of nutrients but also (and often mainly) as a source providing pleasure. Therefore, many consumers may not think in terms of nutrients when purchasing food or planning meals. The implication is that healthy foods, either with more qualifying or less disqualifying nutrients, need to involve no compromise on taste (Verbeke, 2006). Furthermore, the present study just like most research in this field depended on self-reported attitudes and behaviours. Although such self-reported and subjective opinions provide valuable insights into consumers basic attitudes, they likely suffer from so-called social desirability bias and hence may deviate from actual behaviour (Fisher, 1993). Therefore, more experimental and observational research on consumers' attention and perception processes are recommended. Finally, the use of an electronic data collection method may have some consequences for the composition of the sample. In this study an overrepresentation of higher educated respondents was obtained, besides the fact that only computer-literate consumers were included in the sample.

The present study focused on consumer interest in nutrition information, assuming that interest is a prerequisite for future information use. However, when consumers are interested in nutrition information, it does not imply that they want to get this information from food labels and plan to use it (Grunert & Wills, 2007). Also consumers' claimed interest through claimed importance does not necessarily translate into use of the information, as well as into choice and dietary behaviour. Perceived importance is only one step in the elaboration and decision-making process, but is a crucial one because it is very unlikely that consumers pay attention to and use something they personally not find important (Verbeke, 2008). Further research is needed to confirm this causal pathway and to evaluate whether indeed consumers' claimed importance eventually lead to healthier food choices.

Practical implications from this study mainly pertain to communication strategies through food information provision across countries and food products. As no important difference was found between countries regarding the perceived importance of both qualifying and disqualifying nutrients, provision of information about the same nutrients on food labels across countries is proposed. The labelling format is perhaps more important as suggested by Möser et al. (2010) who found that whereas most consumers in Belgium indicated a preference for the GDA, in Germany the TL was favoured most. More important than cross-country differences were the differences in perceived nutrient importance according to the level of health consciousness, age, gender and diet status, which may require a segmentation and targeted information provision. Foods with a healthy nutrient profile for example could include nutrition information on both qualifying and disqualifying nutrients, as more health conscious consumers perceive disqualifying and qualifying nutrients as important in food choices. Also foods marketed to women should better include information on both types of nutrients as opposed to foods targeted at men for whom the nutritional value is considered less important. Food products targeted at older consumers would also better emphasise both disqualifying and qualifying nutrients equally. Special diet foods should continue to focus on disqualifying nutrients, but should not neglect the importance of qualifying nutrients in the group of dieters. Disqualifying nutrients were found to play an important role for consumers who pay attention to the nutrient content of a food for a specific reason (e.g. because they are on a diet or face some form of allergy). For individuals with a higher level of health consciousness all nutrients seemed more relevant compared to those with a lower level of health consciousness. In other words their interest in nutrients might also be a motivational issue, guided by motivation for (healthy) eating rather than depending on the type of nutrient being communicated.

In conclusion, this chapter indicated an overall high importance placed by consumers on qualifying nutrients, while for disqualifying nutrients the perceived importance varied more across consumer groups. With the insights obtained from this chapter, two recommendations can be formulated. The first concerns the development of communication strategies using information on the same nutrients across European countries in order to contribute to consumers' awareness of the nutrients. A second recommendation arising from this chapter is to balance the information of disqualifying and qualifying nutrients in communication strategies.

PART II

Case study 1: Organic vegetables

Part II of this doctoral dissertation (Chapters 3 to 5) covers the first case study which deals with the role of the organic claim (i.e. information on whether the food is organically produced) in consumers' health-related quality perception of vegetables as well as its influence on nutrient and contaminant intakes. The purpose of Part II is twofold. First, the agreement between objective and subjective (or perceived) health-related quality with regard to the nutritional value and safety of organic compared to conventional vegetables is discussed. Therefore, the evidence available on differences in the nutrient and contaminant content between organic and conventional vegetables is compiled and analysed in Chapter 3 (based on Study 1). Consumers' perception related to these aspects and the comparison with the evidence is described in Chapter 4 and is based on Study 2 which is a quantitative consumer survey among adults varying in their use of organic vegetables. The second objective of Part II is to evaluate consumers' health-related perception of "organic" on their consumption of vegetables. This objective is dealt with in Chapter 5 reporting the results of the intake assessment study (Study 3).

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Chapter 3

Science-based evidence on differences in nutrient and contaminant content between organic and conventional vegetables

This chapter is based on:

Hoefkens, C., Sioen, I., De Henauw, S., Vandekinderen, I., Baert, K., De Meulenaer, B., Devlieghere, F., & Van Camp, J. (2009). Development of vegetable composition databases based on available data for probabilistic nutrient and contaminant intake assessments. *Food Chemistry, 113*(3), 799-803.

Hoefkens, C., Vandekinderen, I., De Meulenaer, B., Devlieghere, F., Baert, K., Sioen, I., De Henauw, S., Verbeke, W., & Van Camp, J. (2009). A literature-based comparison of nutrient and contaminant contents between organic and conventional vegetables and potato. *British Food Journal, 111*(10), 1078-1097.

Abstract

The increasing demand for organic foods is explained mainly by consumers' concerns about the quality and safety of foods and their perception that organically produced foods are healthier and safer than conventional foods. Based on internationally available secondary data of nutrient and contaminant concentrations in organic and conventional vegetables (carrots, tomatoes, lettuce, spinach and potato), this chapter aims to investigate the scientific validity of nutrition claims as "no vegetable has higher amounts of nutrient X than organic vegetables" and "no vegetable has lower amounts of contaminant Y than organic vegetables". Detailed nutrient and contaminant databases were developed for organic and conventional vegetables separately. Non-parametric (Mann-Whitney U-test) methods were used to detect significant differences between both types of vegetables. A chi-square test was used to compare the incidence of pesticide residues in organic and conventional vegetables. From a nutritional and safety point of view, organic vegetables in general were not significantly better than conventional vegetables. For some nutrients and contaminants organic vegetables scored

significantly better but for others they scored significantly worse. Therefore, it becomes difficult to justify general claims indicating a surplus value of organic over conventional vegetables. More data from controlled paired studies are needed to reconsider the use of claims for these organic vegetables in the future.

3.1 Introduction

Organic products in the EU are understood to be those products produced under controlled cultivation conditions in line with the provisions of the European Regulation on organic farming (for agricultural products: EC Regulation 2092/91) (Woese et al., 1997). The sales of organic products in Belgium have increased from about 62 million euro in 1997 till 315 million euro in 2004 showing the increased consumer demand for organic products (National Institute of Statistics, 2008). Market share of organic vegetables in the total Belgian vegetable market is 3.1%. The European market of organic products showed a considerable growth in recent years and represented about 11 billion euro in 2004 (EC, 2005).

Vegetables are an important source of bioactive components like dietary fibre, minerals, trace elements, (pro)vitamins and a broad range of secondary plant metabolites. Due to the presence of these nutrients, the consumption of vegetables is associated with a reduced risk of age-related diseases like cardiovascular diseases and certain forms of cancer (Hung et al., 2004; Riboli & Norat, 2003). The World Health Organization (WHO) recommends to consume at least 400g or five portions of fruits and vegetables (excluding tubers) a day (WHO, 2003). However, vegetables may also contain less favourable components like pesticide residues, natural toxins, mycotoxins, environmental contaminants (heavy metals, polychlorinated biphenyls), nitrate and pathogenic micro-organisms (Dedaza & Diaz, 1994; Malmauret et al., 2002). As such, the consumption of vegetables is subjected to a potential nutritional-toxicological conflict between nutritional recommendations and toxicological safety aspects.

Perceived food safety risks and pesticide-related concerns are significant contributors to an increased consumer demand for organically grown food (Williams & Hammitt, 2001). From a scientific perspective, studies comparing the different aspects of quality (nutrient content, sensory attributes, safety) of organic and conventional vegetables are rather scarce (Bourn & Prescott, 2002; Magkos et al., 2006; Woese et al., 1997; Worthington, 1998). Some trends have been observed (Worthington, 1998). Organic vegetables generally contain lower levels of synthetic pesticide residues than conventional vegetables. Furthermore, no major differences exist in the presence of environmental contaminants in organic and conventional vegetables (Woese et al., 1997). Except for vitamin C for which literature suggests higher contents in organic vegetables compared with the conventional alternative, no strong evidence exists that the nutrient content of conventional and organic vegetables differs (Bourn & Prescott, 2002).

The aim of this chapter is to describe the results of a meta-analysis of the relevant literature published after the establishment of the EU organic regulation in 1991 (EC Regulation 2092/91). After the collection, evaluation and selection of the secondary data, a statistical comparison was made between the content of selected nutrients and contaminants between organic and conventional vegetables. Special attention is given to communication strategies for organic products with regard to the nutritional value and safety.

3.2 Methodology

3.2.1 Development of the database

3.2.1.1 Assembling data sources

Electronic literature searches were performed on the Web of Science, PubMed and Google to retrieve international research studies on the nutritional value and safety of organic and conventional vegetables in order to compare products originating from both cultivation methods. The following key-words were used: organic, conventional, vegetables, [vegetable] (e.g. carrot), nutrient, [nutrient] (e.g. vitamin), contaminant, [contaminant] (e.g. nitrate), agriculture, comparison. Additionally, a manual search of the reference lists of relevant articles was conducted. Government organisations and research institutes who published only abstracts and incomplete data were contacted and asked to contribute full datasets or completed research reports and papers.

The selection of the vegetables and components were based on the availability of appropriate data points for the organic variant of the vegetable, the relevance of a specific component for the considered vegetable and the subgroup to which the vegetable belongs (brassicas, leaf vegetables, stalk vegetables, shoot vegetables, bulb vegetables, tubers, root vegetables, fruiting vegetables, edible fungi and vegetable mixtures). After searching through various secondary data sources, carrot (root vegetable), tomato (fruit vegetable), lettuce, spinach (leaf vegetables) and potato (tuber) were retained. The following classes of nutrients and contaminants were included: vitamins and pro-vitamins (vitamin C, carotenoids: β-carotene, lycopene, lutein), minerals (potassium, calcium), secondary plant metabolites other than carotenoids (chlorogenic acid, glycoalkaloids), nitrate, heavy metals (cadmium, lead) and pesticides (azoxystrobin, bifenthrin, chloropropham, chlorothalonil, cyfluthrin, deltamethrin, dichlorovos, dimethoate, esfenvalerate, ethoprophos, iprodion, lambda-cyhalothrin, myclobutanil, pirimicarb, tebuconazole and thiabendazole). In total, 74 relevant data sources were identified and included in the meta-analysis – 39 for nutrients and 35 for contaminants. Separate databases (Excel® spreadsheets) were constructed for nutrients and contaminants. Both databases were linked by the type of vegetable and the type of cultivation method (organic, conventional) when performing a risk-benefit analysis.

3.2.1.2 Data documentation

The way foods are described in databases usually depends on the intended use of the databases and the level of detail actually available to data compilers. The primary purpose of the databases described here was to investigate the potential added value of organic versus conventional vegetables on concentration and intake level of nutrients and contaminants, i.e. more beneficial nutrients and less harmful contaminants. For this purpose, descriptive information on the cultivation method was required. Other relevant information included in both the nutrient and contaminant databases was: common name, scientific name, variety, cultivar, vegetable identification code, component identification, additional information on agricultural practice (if needed), country of origin, EU membership (whether or not submitted to the EU regulation), physical form or shape, preservation method, cooking method, number of individual samples or number of sample units per composite sample, (mean) component content with extra statistical data if available (standard deviation (SD), minimum and maximum), unit, analytical method, limit of detection (LOD) (if available), limit of quantification (LOQ) (if available), date of analysis or reporting, purpose (intake assessment or not), type of study (paired or not), reference and reference code. A paired study was defined as a study comparing nutrient and/or contaminant concentrations in organic and conventional foods in pairs. Documentation of the values was done and checked thoroughly in order to facilitate the evaluation and selection of the values and the compilation of the final database.

3.2.1.3 Data evaluation and selection

Data selection was based on the following criteria: it was decided to consider (1) only data points from analysis in the period after the regulation concerning organic food production was established (EC Regulation 2092/91); (2) only data of vegetables cultivated in EU and continents with a similar regulation in place (e.g. USA and Australia); (3) only data expressed on a fresh weight (FW) basis of a well-defined component in an edible part of the raw vegetable. Missing documentation regarding one or more of these criteria was the principal reason for not taking the data into account. Although only these criteria were considered, it is recognized that numerous other factors also could influence the composition of vegetables (e.g. variety, maturity, growing conditions, soil type, etc.). In order to weigh the data according to the quality of the study, a weighing factor was assigned to each data point (paired factor or $W_{i,pair}$, details given later). Data obtained from a paired study received a higher appreciation or weight than those from partly paired or non-paired studies, because of the nature of the study in which other influencing factors than the cultivation method are controlled. A lack of this type of studies is considered to be a major problem when comparing organic and conventional vegetables.

3.2.1.4 Data weighing

When building up a database using secondary data, a number of problems are encountered with respect to food description, number of samples, sampling plan, analytical methods, data sources, LOQ, etc. Different solutions were proposed by Sioen et al. (2007a; 2007b). One of the problems described was related to the application of individual sample units versus composite samples. Both types of data were differentiated by weighing the data according to the number of sample units, such that data obtained from analysing composite samples got a higher probability of occurrence. The weighing factor was defined as $W_{i,unit}$.

A second problem was that analytical results in different publications are reported in different ways. Both results of individual measurements and aggregated results were found in literature. An aggregated value is obtained by taking the mean or median of the individual measurements (sometimes with standard deviation and/or range). Ideally, to generate a distribution curve, information on concentrations in individual samples should be used (WHO, 2000). When such data are not available, WHO suggests using aggregated data. In combining both individual and aggregated results to form a database for the fitting of distribution curves, Sioen et al. (2007b) proposed a second weighing factor $W_{i,meas}$ as a function of the number of measurements on which a data point was based.

For the purpose of comparing organic and conventional vegetables, an additional weighing factor $W_{i,pair}$ was defined and assigned to each concentration data point x_i. The possible weights for $W_{i,pair}$ were arbitrary chosen. When data were obtained from a paired or non-paired study, $W_{i,pair}$ was assumed to be equal to five or one, respectively. The definition of partly paired study was used to describe studies that analysed both organic and conventional vegetables, but with a study design that was not fully documented. For data coming from a partly paired study, a weighing factor $W_{i,pair}$ equal to three was considered. This means that the values from secondary data sources, not giving the appropriate documentation, receive a lower weight. This is also in line with the system for quality index attribution to data from scientific literature or reports proposed within the European Food Information Resource Network (EuroFIR) (Oseredczuk et al., 2007).

In order to have an overall weighing factor $W_{i,final}$ for each data point x_i of the compiled database, the three weighing factors $W_{i,unit}$, $W_{i,meas}$ and $W_{i,pair}$ were multiplied. In order to characterize distributions for each nutrient or contaminant per vegetable and cultivation method, the cumulative probability of occurrence $F(x_i)$ of a data point x_i was calculated as:

$$F(x_i) = \frac{\sum_i W_{i,final}}{\sum_n W_{i,final}} ,$$

where i is the rank number, $W_{i,final}$ is the overall weighing factor and n is the total number of data points within a dataset defined by component, type of vegetable and cultivation method (Sioen et al., 2007a; Sioen et al., 2007b).

3.2.2 Statistical analyses

Data were analysed using SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA). Specifically, the non-parametric Mann-Whitney U-test was used to assess whether the mean concentrations of two groups, organic and conventional vegetables, were statistically different from each other. A chi-square test was applied to compare the frequencies in which pesticide residues occurred between both farming systems. Significance was assessed at $\alpha = 0.05$.

The results are presented in two ways. A first visualisation of the findings is made by means of box plots, which show the central tendency and the variability (dispersion) of a (weighed) data set. The second way to present the results are tables including numerical statistics.

3.3 Results

3.3.1 Nutrients

For the nutrients, vitamin C, β-carotene (provitamin A), potassium, calcium, lycopene, lutein, chlorogenic acid and glycoalkaloids (α-chaconine + α-solanine) were considered. The concentrations of each nutrient were described in one to five vegetables: carrots, tomatoes, lettuce, spinach and potatoes. The nutrient-vegetable combinations being studied, are summarised in Table 3.1.

The literature search identified 39 relevant sources of nutrient data for the selected vegetable groups: 24 peer-reviewed papers (of which 11 paired or comparative studies), 7 food composition databases (Beemster et al., 2001; Danish Institute for Food and Veterinary Research, 2006; Health Canada, 2006; National Public Health Institute of Finland, 2006; Souci et al., 2000; US Department of Agriculture ARS, 2006; vzw Nubel, 2006), 3 reports or databases (of research or consumer organisations), 3 personal communications and 2 proceedings of symposia. The result of the data collection is summarised in box plots, visualising the central tendency and observed variability within the organic and conventional food (Figure 3.1). The number of data points (n) (without weighing) is mentioned in Table 3.1. In total, 802 nutrient concentration data points were included in the meta-analysis of which 198 data points were obtained from paired studies.

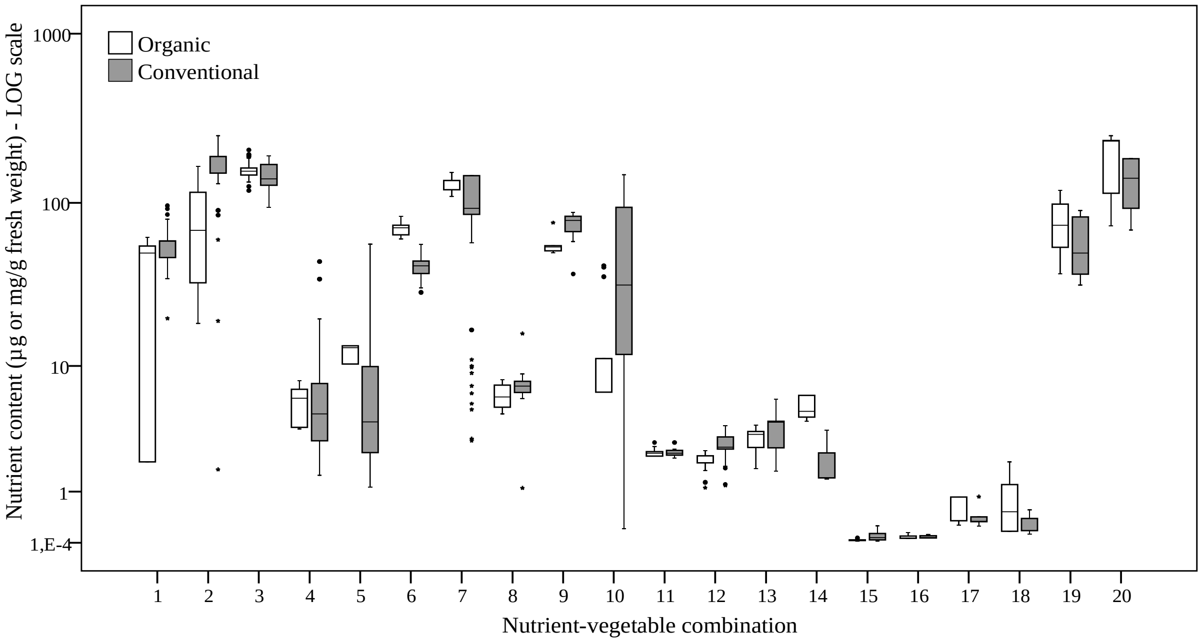

Figure 3.1 Nutrient concentrations in different vegetables, box plots

<u>Legend:</u> 1: vitamin C in carrot; 2: vitamin C in potato; 3: vitamin C in tomato; 4: β-carotene in lettuce; 5: β-carotene in tomato; 6: β-carotene in spinach; 7: β-carotene in carrot; 8: lutein in lettuce; 9: lutein in spinach; 10: lycopene in tomato; 11: potassium in tomato; 12: potassium in carrot; 13: potassium in potato; 14: potassium in lettuce; 15: calcium in potato; 16: calcium in tomato; 17: calcium in carrot; 18: calcium in lettuce; 19: glycoalkaloids in potato; 20: chlorogenic acid in potato.

Table 3.1 Summary of nutrient concentrations (µg or mg/g fresh weight (FW)) in organic (O) and conventional (C) vegetables (number of data points (n), mean, standard deviation (SD))

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Vitamins											
Vitamin C (µg/g FW)	n	21	24	21	25	-	-	-	-	4	17
	mean (SD)	34.97[a] (25.03)	57.34[b] (15.56)	153.71[b] (18.74)	141.66[a] (24.4)					80.48[a] (53.58)	161.66[b] (57.49)
Carotenoids with provitamin A activity											
β-carotene (µg/g FW)	n	21	24	3	44	6	21	6	13	-	-
	mean (SD)	130.42[b] (10.90)	95.08[a] (46.61)	12.30[b] (1.45)	10.91[a] (13.91)	5.79 (1.61)	7.92 (9.01)	70.55[b] (7.40)	40.22[a] (5.91)		
Lycopene (µg/g FW)	n	-	-	5	174	-	-	-	-	-	-
	mean (SD)			13.80[a] (11.46)	51.62[b] (43.50)						
Lutein (µg/g FW)	n	-	-	-	-	6	8	6	12	-	-
	mean (SD)					6.36[a] (1.20)	7.53[b] (2.76)	57.03[a] (9.07)	76.59[b] (10.07)		
Minerals											
Potassium (mg/g FW)	n	7	15	8	15	12	20	-	-	37	48
	mean (SD)	2.07[a] (0.38)	2.73[b] (0.59)	2.41[b] (0.19)	2.35[a] (0.12)	5.24[b] (0.83)	1.81[a] (0.61)			3.08[a] (0.63)	3.64[b] (1.07)
Calcium (mg/g FW)	n	8	16	10	17	14	22	-	-	9	48
	mean (SD)	0.55 (0.26)	0.46 (0.23)	0.08[a] (0.03)	0.08[b] (0.02)	0.72[b] (0.60)	0.27[a] (0.12)			0.04[a] (0.02)	0.09[b] (0.06)
Secondary plant metabolites (other than carotenoids)											
Chlorogenic acid (µg/g FW)	n	-	-	-	-	-	-	-	-	7	8
	mean (SD)									196.96[b] (60.50)	139.09[a] (44.16)
Glycoalkaloids (µg/g FW)	n	-	-	-	-	-	-	-	-	9	11
	mean (SD)									77.00[b] (28.34)	58.07[a] (23.11)

[a, b] indicate significantly different means for specific nutrient-vegetable combination using Mann-Whitney U-test (α = 0.05)

\- indicate no result

For each vegetable and nutrient, the mean concentrations with standard deviations are tabulated for both farming systems (organic versus conventional) (Table 3.1). Statistical analysis revealed that the vitamin C concentration was significantly higher in organic tomato (154 mg/g FW) than in conventional tomato (142 mg/g FW) ($p < 0.05$, Mann-Whitney U-test). However, for carrots and potatoes significantly higher concentrations of vitamin C were found in the vegetable coming from a conventional farming system (carrot: 57 mg/g FW, potato: 162 mg/g FW) than from an organic farm (carrot: 35 mg/g FW, potato: 80 mg/g FW) ($p < 0.05$, Mann-Whitney U-test).

When comparing the mean concentrations of β-carotene between organic and conventional vegetables, the organic vegetable consistently contained significantly higher concentrations of β-carotene compared to the conventional variant ($p < 0.05$, Mann-Whitney U-test), with the exception of lettuce where the difference was not significant, despite a similar tendency as observed for the other vegetables ($p = 0.056$, Mann-Whitney U-test). Opposite results were obtained for some other carotenoids with provitamin A activity, namely lycopene in tomato and lutein in lettuce and spinach (Table 3.1). The results, although not to be generalised for other compounds and vegetables, indicated that the organic vegetables contained significantly lower concentrations of the carotenoids than the conventional vegetable ($p < 0.05$, Mann-Whitney U-test).

For the minerals potassium and calcium, significantly higher concentrations were observed in organic lettuce on the one hand and in conventional tomato, potato and carrot (only for potassium) on the other hand ($p < 0.05$, Mann-Whitney U-test).

Finally, the content of some secondary plant metabolites (other than carotenoids) was compared between organic and conventional potato (Table 3.1). Significantly higher concentrations of chlorogenic acid and glycoalkaloids were found in the organic variant ($p < 0.05$, Mann-Whitney U-test). This observation is in line with the results of beta-carotene in carrot, tomato and spinach, but in contrast with those of beta-carotene in lettuce, lycopene in tomato, and lutein in lettuce and spinach. No specific reason could be identified.

3.3.2 Contaminants

A second database was developed containing concentrations of nitrate, heavy metals (cadmium and lead) and synthetic pesticides in the same vegetables as for nutrients. Table 3.2 shows the different combinations that were studied. In total, the contaminant database contains about 35840 data points coming from 35 different data sources: 10 peer-reviewed

Table 3.2 Summary of contaminant concentrations (µg or mg/g fresh weight (FW)) in organic (O) and conventional (C) vegetables (number of data points (n), number of data points above the LOD (n_D), mean, standard deviation (SD))

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Nitrate (mg/g FW)	n	39	50	-	-	73	1384	16	313	74	322
	mean (SD)	0.197^{a} (0.171)	0.153^{b} (0.045)			1.236^{a} (0.927)	1.973^{b} (0.835)	1.421^{b} (0.534)	1.429^{a} (0.710)	0.133^{a} (0.093)	0.168^{b} (0.094)
Heavy metals (µg/g FW)											
Cadmium	n	40	220	12	43	35	169	7	81	43	251
	mean (SD)	0.026^{b} (0.023)	0.022^{a} (0.018)	0.013 (0.007)	0.011 (0.006)	0.019^{a} (0.013)	0.023^{b} (0.013)	0.079^{b} (0.023)	0.040^{a} (0.022)	0.022^{a} (0.010)	0.029^{b} (0.020)
Lead	n	35	167	-	-	34	105	7	75	44	133
	mean (SD)	0.263^{b} (0.269)	0.105^{a} (0.177)			0.039 (0.083)	0.051 (0.065)	0.055^{a} (0.023)	0.056^{b} (0.133)	0.062^{a} (0.051)	0.136^{b} (0.187)
Pesticides (µg/g FW)											
Azoxystrobin	n (n_D)	46 (0)	225 (3)	-	-	-	-	-	-	-	-
	mean (SD)	0.000^{a} (0.000)	0.012^{b} (0.014)								
Bifenthrin	n (n_D)	-	-	20 (0)	318 (8)	30 (0)	1322 (4)	-	-	-	-
	mean (SD)			0.000^{a} (0.000)	0.025^{b} (0.013)	0.000^{a} (0.000)	0.005^{b} (0.008)				
Chloropropham	n (n_D)	-	-	-	-	-	-	-	-	43 (11)	1767 (1265)
	mean (SD)									0.087^{a} (0.231)	1.380^{b} (2.397)
Chlorothalonil	n (n_D)	-	-	31 (1)	1632 (187)	-	-	-	-	38 (16)	1304 (2)
	mean (SD)			0.003^{a} (0.015)	0.012^{b} (0.045)					0.002^{a} (0.005)	0.005^{b} (0.008)
Cyfluthrin	n (n_D)	-	-	-	-	28 (0)	1485 (9)	-	-	-	-
	mean (SD)					0.000^{a} (0.000)	0.032^{b} (0.086)				
Deltamethrin	n (n_D)	70 (0)	1501 (0)	-	-	-	-	12 (0)	327 (18)	42 (0)	445 (1)
	mean (SD)	0.000^{a} (0.000)	0.012^{b} (0.010)					0.000^{a} (0.000)	0.021^{b} (0.044)	0.000^{a} (0.000)	0.015^{b} (0.012)
Dichlorovos	n (n_D)	-	-	38 (0)	1594 (0)	-	-	-	-	-	-
	mean (SD)			0.000^{a} (0.000)	0.004^{b} (0.004)						
Dimethoate	n (n_D)	39 (0)	1849 (6)	-	-	-	-	-	-	-	-
	mean (SD)	0.000^{a} (0.000)	0.002^{b} (0.004)								
Esfenvalerate	n (n_D)	-	-	-	-	-	-	-	-	18 (0)	1278 (0)
	mean (SD)									0.000^{a} (0.000)	0.013^{b} (0.004)

(continued)

$^{a, b}$ indicate significantly different means for specific nutrient-vegetable combinations using Mann-Whitney U-test (α = 0.05)
\- indicate no result

Table 3.2 Continued

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Pesticides (µg/g FW)											
Ethoprophos	n (n_D)	-	-	-	-	-	-	-	-	36 (0)	1340 (0)
	mean (SD)									0.000[a] (0.000)	0.007[b] (0.003)
Iprodion	n (n_D)	85 (2)	1833 (543)	30 (1)	444 (86)	34 (0)	2611 (378)	-	-	-	-
	mean (SD)	0.001[a] (0.006)	0.015[b] (0.047)	0.010[a] (0.024)	0.025[b] (0.057)	0.000[a] (0.000)	0.229[b] (1.269)				
Lambda-cyhalothrin	n (n_D)	68 (0)	1188 (0)	-	-	-	-	6 (0)	137 (13)	-	-
	mean (SD)	0.000[a] (0.000)	0.006[b] (0.009)					0.000[a] (0.000)	0.008[b] (0.032)		
Myclobutanil	n (n_D)	66 (0)	1773 (2)	29 (0)	1533 (0)	-	-	-	-	-	-
	mean (SD)	0.000[a] (0.000)	0.005[b] (0.004)	0.000[a] (0.000)	0.023[b] (0.001)						
Pirimicarb	n (n_D)	58 (0)	950 (0)	19 (0)	302 (0)	-	-	6 (0)	135 (2)	24 (0)	418 (0)
	mean (SD)	0.000[a] (0.000)	0.008[b] (0.003)	0.000[a] (0.000)	0.010[b] (0.002)			0.000[a] (0.000)	0.012[b] (0.007)	0.000[a] (0.000)	0.010[b] (0.001)
Tebuconazole	n (n_D)	48 (0)	1610 (0)	-	-	-	-	-	-	-	-
	mean (SD)	0.000[a] (0.000)	0.010[b] (0.000)								
Thiabendazole	n (n_D)	-	-	-	-	-	-	-	-	34 (0)	1749 (88)
	mean (SD)									0.000[a] (0.000)	0.025[b] (0.106)

[a, b] indicate significantly different means for specific nutrient-vegetable combinations using Mann-Whitney U-test ($\alpha = 0.05$)

\- indicate no result

papers (including 4 paired studies), 23 reports and/or databases of governments and research institutes and 2 personal communications. The number of paired data points is about 123. For nitrate and the heavy metals cadmium and lead, the variability and some statistics are illustrated as box plots (Figures 3.2 and 3.3).

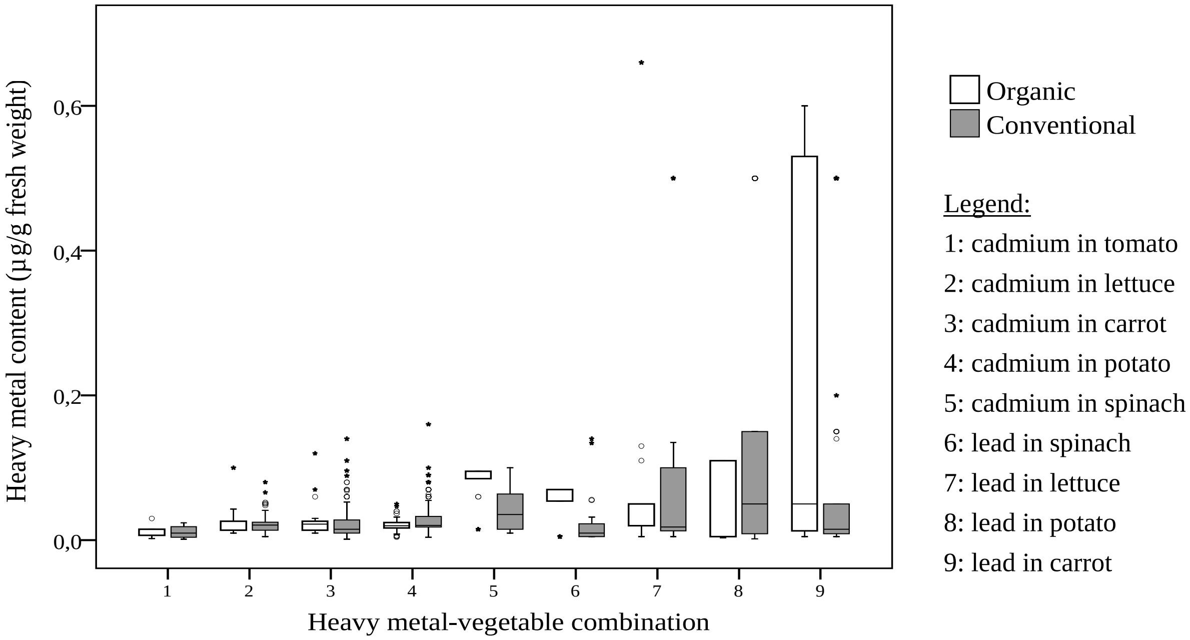

Figure 3.2 Heavy metal concentrations in different vegetables, box plots

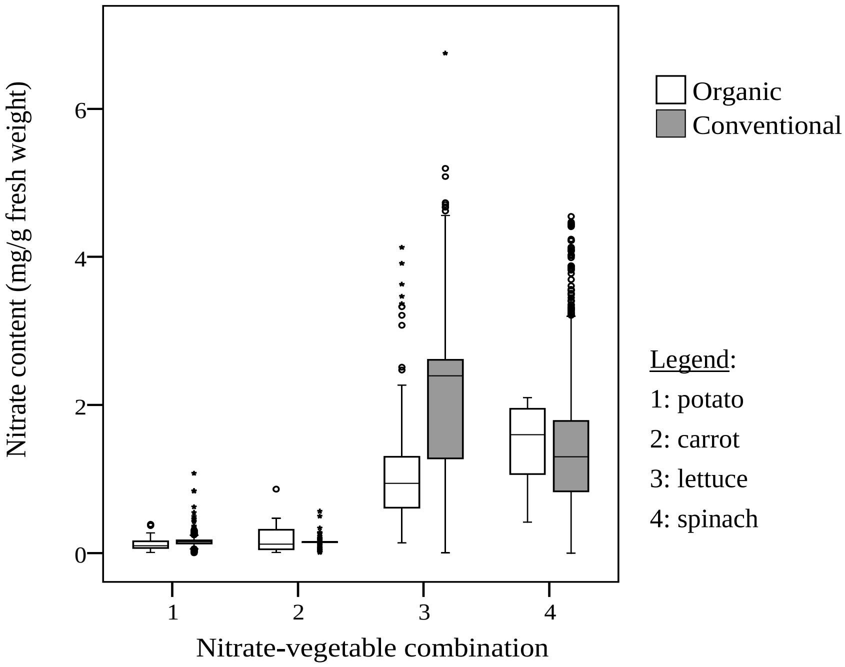

Figure 3.3 Nitrate concentrations in different vegetables, box plots

Table 3.2 gives an overview of the number of pesticide concentration data (without weighing) above and below the LOD and the mean concentration for organic and conventional vegetables. Most of the collected data for synthetic pesticide residues were present at undetected levels (< LOD). In the case of organically grown foods, these non-detects (NDs) were systematically replaced by zero, following the recommendation of the Office of Pesticide Programs (US Environmental Protection Agency, 2000). By law, organic foods are not to be treated with synthetic pesticides (EC Regulation 2092/91). For the pesticide-treated foods like conventionally grown vegetables, the preferred approach is to use a residue value of ½ LOD (or ½ LOQ) if an LOD has not been determined) (US Environmental Protection Agency, 2000).

Given the prohibition of using synthetic pesticides and synthetic fertilizers (containing nitrogen) in organic farming systems, it is reasonable to assume that organically grown foods contain lower concentrations of synthetic pesticide residues and nitrates compared to conventionally grown foods. This assumption was supported in general by statistical analysis, with the exception of nitrate in spinach where the organic alternative contained significantly higher amounts of the contaminant (Table 3.2). The incidence of detectable residue levels of chloropropham in conventional potato was significantly higher than that of the organic variant ($p < 0.05$, chi-square test). More surprising was the significantly higher incidence of chlorothalonil in organic versus conventional potato ($p < 0.05$, chi-square test) although the concentration was significantly lower. The incidence of iprodione was significantly higher in conventional carrot, tomato and lettuce compared to the organic vegetable ($p < 0.05$, chi-square test). Nevertheless, when residues of pesticides were found in conventional vegetables, they were well below the statutory maximum amount or maximum residue limit. For cadmium and lead, significantly higher or lower concentrations and even insignificant differences in concentrations were found depending on the vegetable (Table 3.2).

3.3.3 The nutritional-toxicological conflict

Vegetables containing both beneficial nutrients and harmful contaminants can be considered as a conflict model between dietary recommendations and toxicological safety assurance. The nutritive and toxicological value of vegetables depend on numerous factors like the quality of the environment (air, water, soil and climate), cultivars, pest and disease incidence, and post-harvest practices (Holden, 2002; Rembialkowska, 2007; Zhao et al., 2006). Extensive efforts have been made to understand the interactions between plants and their environment in order to explain the factors that influence plant composition. These efforts have resulted in two main theories, the carbon/nitrogen (C/N) balance theory and the growth/differentiation balance hypothesis (GDBH), which are applied to explain potential differences in the nutrient and contaminant content between organic and conventional foods (Brandt & Molgaard, 2001; Rembialkowska, 2007). The C/N balance theory states that plants will first synthesise components with a high nitrogen content (e.g. proteins for growth and N-containing secondary plant metabolites) when nitrogen is readily available. When nitrogen is limiting for growth, plants will rather make carbon-containing components (e.g. starch and non-N-containing secondary metabolites). The more general GDBH claims that plants, depending on the available resources, will optimise their investment in processes directed to growth or differentiation (e.g. increased formation of defence compounds).

From the above theory it was expected that organic vegetables contained less nitrate and as such more non-N-containing secondary plant metabolites and vitamin C because of the replacement of synthetic fertilisers (N immediately available) by animal manure (N slowly released) in organic farming systems. Two conflict models were worked out: (1) vitamin C versus nitrate in carrots and potatoes and (2) β-carotene versus nitrate in lettuce and spinach (Figures 3.4 and 3.5).

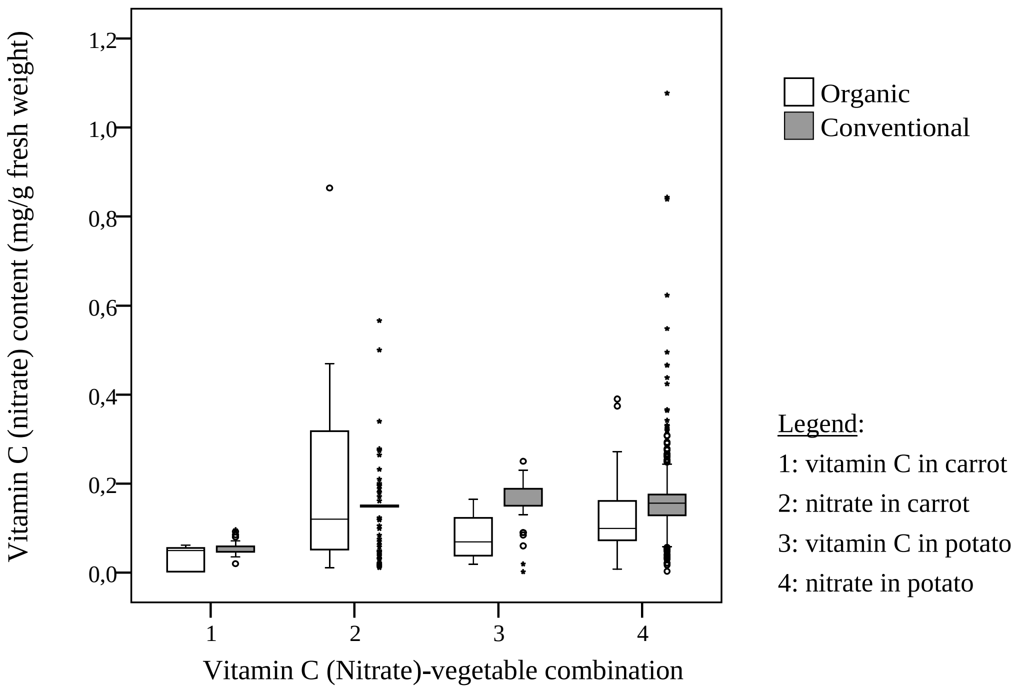

Figure 3.4 Vitamin C versus nitrate concentrations in different organic and conventional vegetables, box plots

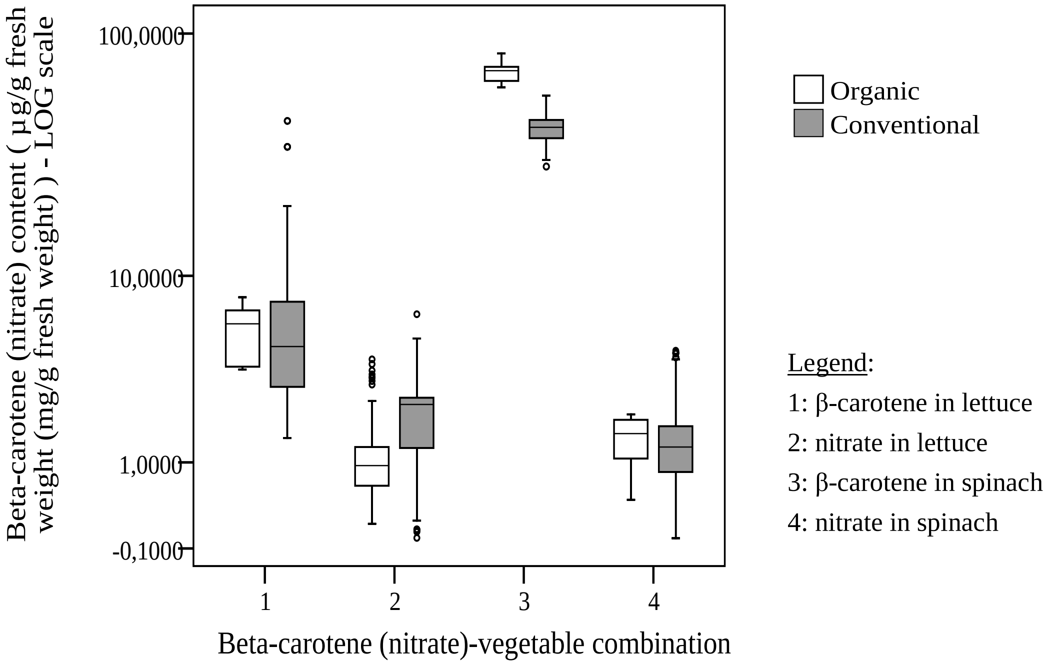

Figure 3.5 β-carotene versus nitrate concentrations in different organic and conventional vegetables, box plot

When excluding outliers, the box plots of vitamin C and nitrate in organic carrots showed respectively a downward and upward variation. This observation was in line with above theories. However, these theories are less strong in explaining the small, although significant ($p < 0.05$) differences in vitamin C and nitrate concentrations between the organic and conventional carrot. For potatoes a larger difference in nitrate content was observed, which is translated in a larger difference in vitamin C content. Following the theories, the higher nitrate content in conventional potatoes compared to organic potatoes should lead to a lower vitamin C content in the conventional versus organic potato, which was not the case. The second conflict model, illustrated in Figure 3.5, indicated a large within-product variation of β-carotene and nitrate in conventional lettuce with a significantly higher nitrate content but similar β-carotene content ($p > 0.05$) in conventional compared to organic lettuce. The results for spinach showed significantly higher amounts of β-carotene and nitrate in the organically grown vegetable compared to the conventional variant. Both examples indicate a certain mismatch between theory and evidence.

3.4 Discussion

During the compilation of the nutrient and contaminant databases, several problems were encountered influencing the comparability of the concentration data within and between organic and conventional vegetables. Potential solutions for the problems as a result of intra-variability of nutrient and contaminant concentrations (i.e. within a food) were proposed by Sioen et al. (2007a; 2007b). In this chapter a first attempt was made to filter out the intervariability in vegetable composition due to (interacting) confounding factors in order to have a good evaluation of the effect of farming system. The limited number of paired studies currently available necessitated inclusion of non- (semi-) paired data sources. Therefore, a weighing factor was introduced to enable distinction between data obtained from paired, semi-paired (not giving appropriate details) and non-paired studies. An additional problem was the selection of the value of the weighing factors. Here the weighing factors were arbitrary chosen as no validation method could be found in literature. The choice of allocating a higher weight to paired data compared to non- (semi-) paired data was trivial. In order to define standardised weighing factors and to create more uniformity and traceability in the evaluation of the data quality, it may be interesting for future research to adopt EuroFIR's system for quality index attribution to data from scientific literature or reports (Oseredczuk et al., 2007). The system is a quality evaluation system based on four categories: (1) food description, (2) component identification, (3) sampling plan and (4) sample analysis. Within each category a set of criteria is proposed and the scores for each criterion (5 for high quality, 3 for intermediate quality, and 1 for low quality) are summed to form the quality index belonging to a specific data point.

A final problem was related to the statistical treatment of concentrations below the LOD or LOQ. In the present study the undetected data obtained from organic foods were systematically replaced by zero and the data from conventional foods by half of the LOD (or one quarter of the LOQ). It is generally recommended to use a residue value of zero for the proportion of the data set corresponding to the percentage of the commodities known not to be treated with pesticides (US Environmental Protection Agency, 2000). This proportion is clearly defined in the case of organic foods, but rarely known for conventional foods. Moreover, when the proportion of NDs in a data set exceeds 50% – as it is the case here – the handling of NDs should be considered on a case-by-case basis (US Environmental Protection Agency, 2000). As no general rule of thumb exists, it is useful to consider the potential effect of the substituted values by performing a sensitivity analysis. When comparing the results between different approaches, for example NDs = 0 versus NDs = ½ LOD for conventional samples, the number of significantly higher pesticide residue levels in conventional vegetables compared to organic vegetables decreased from 27 to 3 (of a total of 27). Whatever the approach, it should be recommended to inform the reader about the approach used in order to avoid wrong interpretations.

The primary aim of the meta-analysis was to map the potential differences in nutritional and toxicological value between organic and conventional vegetables. The meta-analysis found that: (1) vitamin C concentrations were significantly higher in conventional carrots and potatoes, but significantly lower in conventional tomato compared to the organic product, (2) the concentration of β-carotene in three of the four vegetables was significantly higher in the organically grown vegetable, (3) the organic vegetables (except potatoes) had a significantly lower content of some secondary plant metabolites (except for β-carotene) compared to the conventionally grown food, (4) for both minerals potassium and calcium various results were obtained, (5) no trend was observed for the heavy metals cadmium and lead, (6) nitrate was present in significantly higher amounts in three of the four conventional vegetables (no data for tomato) and (7) concentrations of synthetic pesticide residues were significantly higher in the conventional product but still lower than the statutory maximum amount. The meta-analysis was performed on the basis of available scientific evidence which is usually identified and compiled in a first phase by systematic reviews. Inconclusive findings observed in reviews concern especially the nutritional value (except vitamin C) of organic foods compared to conventional foods (Bourn & Prescott, 2002; Brandt & Molgaard, 2001; Magkos et al., 2003b; Rembialkowska, 2003; Woese et al., 1997; Worthington, 2001).

Evidence-based communication is important in order not to mislead consumers. Based on existing consumer science literature, it appears that consumers in general perceive organic foods as being healthier and safer (Bonti-Ankomah & Yiridoe, 2006). Present large-scale meta-analysis indicated, however, that scientific evidence is currently lacking to unconditionally recommend organically grown vegetables over conventional vegetables, especially in relation to the nutritional value. As a result, nutrition claims on organic vegetables are considered not to be possible at the moment. The Food and Agriculture Organization suggests that “organic” should be seen as a process claim, indicating to consumers that a product was produced according to the organic regulation, rather than a product claim (including nutrition and health claims) (FAO, 1999). More well-controlled paired studies and a standardisation of the format for reporting are needed to determine which claims could possibly be made in the future. The question remains whether farmers will be able to control for all previously mentioned confounding factors.

3.5 Conclusions

In this chapter, evidence was provided that organically grown vegetables in general contained significantly lower concentrations of synthetic pesticide residues and nitrates. On the other hand evidence was lacking to conclude that organic farming usually enhances the nutritional value compared to conventional farming systems. Although conflicting messages were found between single research studies, our conclusions were in accordance with earlier made reviews. When looking at the effect of the farming system on the balance between nutrients and contaminants, no systematic trend was found as proposed in the C/N balance theory and the GDBH. Further research is recommended to understand better (1) the relative nutritional value and (2) the nutritional and toxicological conflict related to organic and conventional vegetables and, as such, to come to evidence-based communication strategies for both farming systems. In order to achieve this aim, more paired studies of high quality are needed. Based on current findings, nutrient and/or contaminant comparative claims for organic vegetables cannot be scientifically proven.

Chapter 4

Nutritional value and safety of organic vegetables: consumer perception versus scientific evidence

This chapter is based on:

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Abstract

The present chapter aims to explore and compare consumer perception and scientific evidence related to food quality and food safety aspects of organic versus conventional vegetables. Primary data on consumer perception were gathered in 2006-2007 through a consumer survey with Flemish adults (n = 529) and compared with scientific evidence from literature (Chapter 3). Consumers of organic and conventional vegetables were selected by means of a convenience sampling procedure. Subjects were asked to complete a self-administered questionnaire concerning the perception of the nutritional value and safety of organic relative to conventional vegetables. Data processing and analysis included descriptive analyses (frequency distributions), data reduction (Cronbach's alpha test, factor analysis), bivariate analyses (correlations, t-test, ANOVA) and a multivariate analysis (stepwise multiple regression). Organic vegetables were perceived as containing less contaminants and more nutrients, and as such, as being healthier and safer compared to conventional vegetables. However, not enough evidence is currently available in literature to support or refute such perception, indicating a certain mismatch between consumer perception and scientific evidence. The gap between perception and evidence was larger among older consumers with children. The perception was stronger when the consumption frequency was higher, but was independent of gender, place of residence (rural or urban), education and income level. Also non-users on average perceived that organic vegetables have a nutritional and safety advantage over conventional vegetables.

4.1 Introduction

The health benefits of an adequate consumption of vegetables and fruit and the role of this food group in preventing a variety of diseases such as cardiovascular diseases, certain cancers and obesity, have been recognised for quite some time now (Bes-Rastrollo et al., 2006; Hu, 2003; Ness & Powles, 1997; Steinmetz & Potter, 1996). In relation to other foods, vegetables and fruits are important sources of vitamins, minerals, trace elements, dietary fibre and a large variety of beneficial phytochemicals. Although vegetables are perceived as healthy by the majority of consumers, the dietary recommendation of eating at least five portions of fruits and vegetables a day is often not met by an important share of the population in many countries (Pomerleau et al., 2004; WHO, 2003).

Besides nutrients, fruit and vegetables may also contain less favourable substances like environmental contaminants (e.g. nitrates, pesticide residues) and pathogenic micro-organisms (and their metabolites). Growing consumer concerns about the quality of foods due to the presence of these harmful contaminants are considered to be one of the major motives for the increased demand for organic foods (Magkos et al., 2003a). The popularity of organic foods is reflected in the growth of the organic foods market in Belgium and other European countries (Abando & Rohner-Thielen, 2007; Samborski et al., 2007). When comparing the market share of organic product groups in the Belgian market, it seems that vegetables have the second largest share after eggs. The present study is focused on vegetables.

The way in which consumers perceive organic products has been investigated in a number studies, as has been reviewed for example in Bonti-Ankomah and Yiridoe (2006). However, until now no study on consumer perception of organic food in general, or organic vegetables in particular, has yet been undertaken in Belgium. Based on existing consumer science literature, organic foods are mainly perceived as healthier and safer compared to conventional foods. From a scientific point of view however, there is currently not enough evidence to unconditionally recommend organic foods over conventionally produced foods (Hoefkens et al., 2009a; Williamson, 2007). In response to a potential mismatch between consumer perceptions and scientific facts, the objective of this chapter is to explore Flemish consumer’s (subjective) perception of organic vegetables, relative to conventional vegetables, and to compare these findings with current scientific (objective) knowledge and consensus. This investigation and comparison generate new insights for further research and communication for both organic and conventional vegetables.

4.2 Methodology

4.2.1 Study design and population

A quantitative survey was conducted in Flanders, Belgium, during the period of December 2006 - February 2007 by means of structured questionnaires. The present study was part of a research project about comparing organic food and farming with the conventional alternative (Van Huylenbroeck et al., 2009). The target population for the consumer survey were adults (age range 18-84) differing in their use of organic food products (from non-users to heavy-users) and being at least now and then responsible for food purchase. To obtain the group of heavy users of organic products, 600 of a total of 1200 questionnaires were provided to randomly selected members of the Flemish organisation VELT that promotes an ecological lifestyle. The remainder questionnaires were distributed to non-VELT members using a convenience sampling procedure. Efforts were made to obtain a sample as representative as possible of the Flemish population, namely by keeping track on the numbers in the different socio-demographic groups. In total, 1200 individuals were personally contacted and asked to complete a self-administered questionnaire. The questionnaires were handed over to participants or sent by post. From the total of 1200 questionnaires, 553 were returned and 529 were useful for statistical analysis (which corresponds to a valid response rate of 44%). About half of the final valid sample (n = 266) were member of VELT, thus people who can be considered to be more highly involved in organic food. It should be noted that this subgroup was excluded from descriptive analyses as reported further in this chapter when talking about "Flemish consumers". The reason is that the non-members were considered to be more representative for the overall (Flemish) population.

The distribution of the characteristics such as gender, age, place of residence (rural versus urban based on urbanisation degree, respectively below and above 300 inhabitants/km²) (Lauwers et al., 2004), presence and age of children, education and income covered a wide range and are shown in Table 4.1. Concerning the age, a small over-sampling of older respondents occurred due to the fact that respondents had to be responsible for food purchasing. The overrepresentation of higher educated respondents and the higher proportion of respondents with adult children and with a relatively higher income is probably due to the convenient character of the sampling. Therefore, it is not advisable to generalise the findings beyond the sample characteristics.

Table 4.1 Sample characteristics (%, n = 529)

Gender	Male	46.9
	Female	53.1
Age	18-25 years	8.9
	26-40 years	22.3
	41-50 years	32.1
	51-65 years	26.7
	65+ years	10
	Mean (SD)	46.7 (14.1)
Children in the household	Yes	76.4
	No	23.6
Education	Lower secondary	5.9
	Upper secondary	34.2
	Higher	59.9
Family income	< 1000 €/month	2.8
	1000-1500 €/month	10
	1500-2000 €/month	12.7
	2000-2500 €/month	15.5
	2500-3000 €/month	16.1
	> 3000 €/month	27.4
	No answer	15.5

4.2.2 Questionnaire

The questionnaire aimed to assess consumers' perception of organic vegetables relative to conventional vegetables with regard to food quality attributes in general, and food safety in particular. Using several statements and answer categories on a 7-point Likert scale ranging from "totally not agree" over "neutral" to "totally agree", respondents were asked to evaluate the potential added value of organic vegetables on seven attributes: (1) nutritional value (in general), (2) health, (3) safety and (4) level of contamination (both in general and more specific in terms of (5) pesticide residues, (6) pathogenic micro-organisms, (7) mycotoxins) (Table 4.2). Based on the mean scores for the individual attributes, a general added value score was computed.

Finally, to identify consumer segments, respondents were also questioned about their consumption behaviour and socio-demographic characteristics including gender, age, place of residence, education, family income and household composition.

4.2.3 Statistical analyses

A preliminary version of the questionnaire was pretested in a small sample of 15 students for clarity of content, language/wording, overall understanding and length of the survey. The students were given the instruction to complete the questionnaire while checking on these points. Together with feedback from the expert committee of the project which consisted of scientists, SME's and government, the questionnaire was refined and finalized. Statistical analyses were carried out with the software program SPSS 15.0 (SPSS Inc., Chicago, IL, USA). Significance was assessed at $\alpha = 0.05$.

Consumer perception measures are summarized in table format as mean scores and standard deviations on a 7-point Likert scale. In addition, frequency distributions are provided in recoded categories ((slightly) negative perception, neutral, (slightly) positive perception). Cronbach's alpha was used to estimate the proportion of variance that is consistent in a set of scores. Following factor analysis and reliability testing, a composite measure of perception related to organic vegetables was computed. Independent samples t-tests and ANOVA F-tests with Duncan post hoc comparison of mean scores were applied for detection of differences in consumer beliefs and perception between different socio-demographic and user groups (non-user, light user, medium user, heavy user of organic fruit and vegetables). Stepwise linear regression was used to determine the predictive value of the nutritional value and safety attributes for the health perception.

4.3 Results

4.3.1 Sample characteristics

An interesting criterion used to subdivide the study population is the claimed share of organic in total claimed vegetable consumption. Respondents with a zero contribution were referred to as non-users. The contribution of organic vegetables for light, medium and heavy users was respectively defined at ≤ 20 %, 20-80 % and > 80 %. Based on these definitions, about half of the sample were classified as medium users (47 %), whereas less than 10 % were non-users (9 %). Light users and heavy users were almost equally represented, respectively 21 % and 23 %. The socio-demographic profile of the sample is represented in Table 4.1.

4.3.2 General perception of organic versus conventional vegetables

The results of the consumer perception survey on organic versus conventional vegetables are reported in Table 4.2. The mean perception scores on all the attributes were around five on a 7-point Likert scale and differed significantly between organic and conventional vegetables. This indicates that, in general, consumers perceived organic vegetables positively, and more positively than conventional vegetables. Compared to conventional vegetables, they believed that the nutritional value and safety of organic vegetables is better. It is apparent from Table 4.2 that the highest mean perception scores (in favour of organic vegetables) corresponded to the perceived contaminant content ($\mu = 6.07$) and healthiness ($\mu = 5.94$). A relatively less positive perception was attached to the attributes of microbiological contamination, i.e. less mycotoxins ($\mu = 4.87$) and less harmful micro-organisms ($\mu = 4.85$). With respect to the pesticide residue level and the nutrient content in general, the respondents attributed a mean score of 5.48 and 5.01, respectively. Finally, respondents (slightly) agreed that organic vegetables are more controlled than their conventional alternative.

Table 4.2 Consumers' perception of organic versus conventional vegetables (%, n = 529), mean score and standard deviation (SD) on a 7-point Likert scale[1]

Items: organic vegetables compared to conventional vegetables are/contain…	Totally disagree/ disagree	Slightly disagree	Neutral	Slightly agree	Agree/ totally agree	Mean	SD
General beliefs:							
Healthier	2.8	4.0	9.5	12.3	71.5	5.94	1.38
Better controlled	4.3	7.9	21.2	17.4	49.1	5.22	1.50
Nutrient content belief:							
More nutrients (e.g. vitamins and minerals)	11.3	8.7	18.3	14.9	46.7	5.01	1.79
Contaminant content beliefs:							
Less contaminants (e.g. pesticides and nitrates)	1.7	3.6	6.4	12.9	75.4	6.07	1.25
No synthetic pesticide residues	6.8	7.4	11.5	14.2	60.1	5.48	1.64
Less harmful micro-organisms[2]	6.8	14.4	25.9	15.7	37.2	4.85	1.62
Less mycotoxins[2]	7.4	11.0	28.7	14.0	38.9	4.87	1.62

[1] Categories "totally disagree" and "disagree", and "agree" and "totally agree", from the initial 7-point scale were merged for clarity of presentation; statistical analyses as reported in the text were performed with the original 7-point scale data

[2] Item asked in the negative (or more harmful micro-organisms/mycotoxins); inverse coded for inclusion in composite construct

In order to explore similarities and differences in beliefs and perceptions related to organic vegetables, data were reduced through factor analysis. A principal components factor analysis with varimax rotation of the seven items revealed only one meaningful factor. The Cronbach's alpha coefficient for these items was 0.73, denoting good and acceptable internal consistency reliability (Nunnally, 1978). For further analysis, a composite construct score was computed, hereafter referred to as "perceived added value of organic" relative to conventional vegetables. In case of significant differences in this composite measure, the mean scores for the individual items were also compared between the groups.

4.3.3 Socio-demographic differences in perception of organic versus conventional vegetables

Perceived added value of organic increased with increasing age ($r = 0.288$; $p < 0.01$). Significant differences were observed between the age category 18-25 years and the category above 25 years ($p < 0.001$), with the latter reporting a higher perceived added value of organic. Additionally, in the above 25 age group the perception differed significantly between the subgroups 26-40 years and 51+ years ($p = 0.002$), again with the older age group reporting more positively. On each individual item level, a consistent difference was found between the youngest age group (18-25 years) and the other groups. Respondents with children reported a more positive perception of organic vegetables compared to conventional vegetables ($p < 0.001$). Specifically, the presence of children positively affected the perception on the attributes of pesticide residue level, contaminant content, nutrient content and healthiness ($p < 0.05$). When comparing consumer perception between different income classes, a significantly higher agreement ($p = 0.004$) was observed for respondents with a family income between 1000-1500 €/month as compared to respondents having an income between 2500-3000 €/month. However, no correlation was found between perception and income level ($p > 0.05$). Gender, place of residence and education level had no significant impact on the overall perception of organic having nutritional and safety advantages over conventional vegetables. When considering the mean perception scores for each item and socio-demographic group, consistently the attributes of healthiness and contaminant content were indicated as the main positive attributes of organic vegetables (Table 4.3).

Table 4.3 Socio-demographic differences in consumers' perception of organic versus conventional vegetables (n = 529), mean score and standard deviation (SD) on a 7-point Likert scale

Sample characteristic		Item							
		Healthier	More nutrients	Less contaminants	No synthetic pesticide residues	Less harmful micro-organisms	Less mycotoxins	Better controlled	Overall added value
Gender	Male	5.95 (1.39)	4.99 (1.83)	6.13 (1.18)	5.46 (1.68)	4.82 (1.64)	4.88 (1.63)	5.29 (1.43)	5.36 (1.00)
	Female	5.94 (1.38)	5.02 (1.75)	6.02 (1.30)	5.49 (1.60)	4.87 (1.61)	4.86 (1.62)	5.15 (1.56)	5.31 (1.03)
Age (years)	18-25	4.66[a] (1.55)	3.64[a] (1.54)	5.23[a] (1.18)	4.64[a] (1.54)	4.36[a] (1.52)	4.13[a] (1.24)	4.60[a] (1.41)	4.43[a] (0.77)
	26-40	5.69[b] (1.61)	5.02[b] (1.79)	5.94[b] (1.25)	5.05[a] (1.79)	4.68[a,b] (1.51)	4.80[b] (1.41)	5.13[b] (1.45)	5.21[b] (1.00)
	41-50	6.09[c] (1.21)	5.09[b] (1.67)	6.14[b] (1.20)	5.58[b] (1.52)	4.88[a,b] (1.49)	4.91[b] (1.63)	5.22[b] (1.46)	5.40[b,c] (0.98)
	51-65	6.30[c] (1.07)	5.14[b] (1.80)	6.28[b] (1.22)	5.82[b] (1.57)	4.99[b] (1.83)	5.06[b] (1.76)	5.45[b] (1.44)	5.55[c] (0.96)
	65+	6.23[c] (1.22)	5.57[b] (1.82)	6.32[b] (1.24)	5.94[b] (1.47)	5.19[b] (1.69)	5.06[b] (1.82)	5.34[b] (1.84)	5.62[c] (1.00)
Children in the household	Yes	6.11[y] (1.27)	5.12[y] (1.78)	6.17[y] (1.23)	5.65[y] (1.55)	4.92[y] (1.63)	4.93[y] (1.66)	5.28[y] (1.50)	5.44[y] (0.98)
	No	5.42[x] (1.61)	4.66[x] (1.76)	5.74[x] (1.25)	4.92[x] (1.78)	4.63[x] (1.58)	4.67[x] (1.49)	5.02[x] (1.49)	5.00[x] (1.06)
Education	< 18 yr	6.39[b] (1.05)	5.74[b] (1.44)	6.06 (1.63)	6.03 (1.52)	4.87 (1.69)	5.32 (1.72)	5.55 (1.55)	5.61 (1.02)
	≤ 18 yr	6.08[a,b] (1.30)	5.31[a,b] (1.71)	6.06 (1.31)	5.51 (1.56)	4.78 (1.59)	4.85 (1.68)	5.23 (1.54)	5.40 (1.02)
	> 18 yr	5.82[a] (1.44)	4.76[a] (1.82)	6.08 (1.17)	5.40 (1.68)	4.89 (1.64)	4.84 (1.58)	5.18 (1.48)	5.27 (1.00)
Family income (€/month)	< 1000	6.33[b] (1.11)	5.40[a,b] (1.88)	6.00 (1.31)	5.60[a,b] (1.84)	4.73[a] (2.15)	4.73 (1.75)	4.80[a] (2.08)	5.33[a,b] (1.11)
	1000-1500	6.26[b] (1.24)	5.68[b] (1.37)	6.15 (1.46)	5.92[b] (1.21)	5.49[b] (1.51)	4.94 (1.74)	5.72[b] (1.63)	5.68[b] (1.00)
	1500-2000	5.97[a,b] (1.36)	4.96[a,b] (1.75)	6.18 (1.21)	5.60[a,b] (1.72)	4.63[a] (1.67)	4.96 (1.54)	5.31[a,b] (1.41)	5.34[a,b] (1.11)
	2000-2500	6.00[a,b] (1.40)	5.01[a,b] (1.74)	6.22 (1.14)	5.82[a,b] (1.34)	4.91[a,b] (1.61)	4.87 (1.71)	5.43[a,b] (1.33)	5.49[a,b] (0.92)
	2500-3000	5.91[a,b] (1.42)	5.02[a,b] (1.70)	5.76 (1.39)	5.09[a] (1.82)	4.54[a] (1.67)	4.85 (1.56)	5.12[a,b] (1.36)	5.20[a] (0.91)
	> 3000	6.02[a,b] (1.25)	4.90[a,b] (1.87)	6.26 (1.09)	5.48[a,b] (1.61)	4.84[a,b] (1.57)	4.84 (1.65)	5.19[a,b] (1.51)	5.33[a,b] (0.96)
	No answer	5.49[a] (1.62)	4.72[a] (1.96)	5.78 (1.28)	5.11[a] (1.77)	4.90[a,b] (1.53)	4.85 (1.57)	4.83[a] (1.58)	5.10[a] (1.15)
Residence	Urban	6.00 (1.33)	5.02 (1.80)	6.12 (1.20)	5.50 (1.60)	4.87 (1.66)	4.87 (1.66)	5.29 (1.50)	5.37 (1.02)
	Rural	5.81 (1.47)	4.96 (1.77)	5.98 (1.29)	5.47 (1.72)	4.80 (1.56)	4.87 (1.56)	5.09 (1.53)	5.27 (1.01)

[a,b,c] indicate significantly different means using ANOVA F-tests with Duncan post hoc test on a 7-point scale (1 = totally disagree; 7 = totally agree)

[x,y] indicate significantly different means using independent samples t-tests on a 7-point scale (1 = totally disagree; 7 = totally agree)

4.3.4 Organic versus conventional vegetables: differences in perception according to consumption level

As could be expected, heavy users (> 80 % of vegetable consumption is organic) on average hold the strongest favourable beliefs about organic compared to conventional vegetables ($p < 0.001$). Compared to the other user groups, heavy users perceived organic vegetables as being significantly healthier ($\mu = 6.66$) and better controlled ($\mu = 5.87$), and containing more nutrients ($\mu = 5.87$), less contaminants ($\mu = 6.55$), no synthetic pesticide residues ($\mu = 6.31$), less harmful micro-organisms ($\mu = 5.18$) and less mycotoxins ($\mu = 5.26$) ($p < 0.05$). The mean scores indicated that the attributes of healthiness and contamination level were the major arguments in favour of organic vegetables (Table 4.4). Medium users (organic's claimed share between 20 and 80 %) perceived organic vegetables more positively than light users (≤ 20 %) ($p < 0.001$), who in turn had a slightly better perception than non-users ($p > 0.05$). Less expected was that also non-users on average believed in the nutritional and safety benefits of organic vegetables compared to the conventional alternative. This can be explained by the fact that non-users have other than food content related arguments for not buying organic foods. Preferences of consumer groups and underlying arguments as determined in a choice experiment are described in another paper (Mondelaers et al., 2009b). When comparing medium users with light users on individual item level, the mean perception scores for all attributes were significantly higher for the first group ($p < 0.05$) except with respect to perceived contamination with harmful micro-organisms where no significant difference was found ($p = 0.123$). Also medium, light and non-users assigned the highest score to the attributes of healthiness and contaminant level (Table 4.4).

Another grouping variable considered here is the membership in the Flemish organisation VELT that promotes an ecological lifestyle. The mean perception scores for the seven-item construct as well as for the individual items were, as could be expected, significantly higher for the members in comparison with non-members ("Flemish population") ($p < 0.05$). Regardless of the membership, the items concerning contaminant concentration and healthiness were again the major arguments in favour of organic vegetables (Table 4.4). When comparing the members with the heavy user group of non-members, no significant differences were found in the overall perception. However, the perception of the healthiness and mycotoxin level differed significantly between both groups, with a higher score for the members.

Table 4.4 Consumers' perception of organic versus conventional vegetables in function of consumption behaviour and VELT membership (n = 529), mean score and standard deviation (SD) on a 7-point Likert scale

Sample characteristic		Item							Overall added value
		Healthier	More nutrients	Less contaminants	No synthetic pesticide residues	Less harmful micro-organisms	Less mycotoxins	Better controlled	
User group	Non-user	4.96^{a} (1.88)	4.34^{a} (1.85)	5.47^{a} (1.59)	4.66^{a} (1.90)	4.28^{a} (1.51)	4.45^{a} (1.49)	4.83^{a,b} (1.66)	4.70^{a} (0.98)
	Light user	5.27^{a} (1.55)	4.20^{a} (1.83)	5.58^{a} (1.34)	4.95^{a} (1.72)	4.63^{a,b} (1.48)	4.48^{a} (1.58)	4.72^{a} (1.38)	4.83^{a} (0.95)
	Medium user	6.09^{b} (1.16)	5.08^{b} (1.67)	6.17^{b} (1.14)	5.47^{b} (1.58)	4.90^{b,c} (1.58)	4.94^{b} (1.53)	5.20^{b} (1.49)	5.37^{b} (0.92)
	Heavy user	6.66^{c} (0.82)	5.87^{c} (1.53)	6.55^{c} (0.95)	6.31^{c} (1.12)	5.18^{c} (1.80)	5.26^{b} (1.81)	5.87^{c} (1.35)	5.99^{c} (0.87)
VELT member	Yes	6.56^{y} (0.83)	5.65^{y} (1.57)	6.53^{y} (0.87)	5.98^{y} (1.35)	5.10^{y} (1.73)	5.20^{y} (1.66)	5.59^{y} (1.38)	5.80^{y} (0.85)
	No	5.32^{x} (1.55)	4.36^{x} (1.76)	5.61^{x} (1.39)	4.97^{x} (1.74)	4.60^{x} (1.47)	4.53^{x} (1.52)	4.84^{x} (1.53)	4.86^{x} (0.94)

$^{a, b, c}$ indicate significantly different means using ANOVA F-tests with Duncan post hoc test on a 7-point scale (1 = totally disagree; 7 = totally agree)

$^{x, y}$ indicate significantly different means using independent samples t-tests on a 7-point scale (1 = totally disagree; 7 = totally agree)

4.3.5 Perceived healthiness of organic vegetables in function of other attributes

The comparison of consumers' health perception of organic and conventional vegetables with the perception of nutritional and safety aspects resulted in significant correlations ($p < 0.01$). In other words, consumers who considered organic vegetables to be healthier than the conventional variant also perceived organic vegetables as containing/being (in decreasing order of correlation): less contaminants ($r = 0.572$), more nutrients ($r = 0.538$), no pesticide residues ($r = 0.435$), safer ($r = 0.387$), less mycotoxins ($r = 0.216$) and less harmful micro-organisms ($r = 0.120$). Despite being significant at $p < 0.01$, the correlation coefficients (r) ranged between 0.120 and 0.572, indicating that the relationships between the health attribute and remaining attributes were rather weak.

Stepwise multiple regression analysis was performed to develop equations involving food quality and food safety attributes that most contributed to the health perception of organic vegetables. The final model and results are shown in Table 4.5. The lower contaminant level was the first variable entered into the equation for predicting the health perception of organic. The second, third and fourth variable entered, were the higher nutrient content, the zero pesticide residue content and the lower mycotoxin level respectively. The variables "better controlled" and "less harmful micro-organisms" did not meet the significance level requirement for entry into the model ($p < 0.05$). Although the absence of pesticide residues in organic increased the R square of the equation, it was obvious that the pesticide residue level did not add to the predictive value of the model.

The correlation and stepwise regression analyses indicated that the contaminant and nutrient content were the two major drivers for consumers to believe in the health advantage of organic over conventional vegetables. In addition, it appeared that other than food related arguments contributed to consumers' health perception of organic vegetables, as only 48.6 % of the total variation in health perception was explained by the proposed model of four variables.

Table 4.5 Stepwise linear regression: explanatory variables for perceived health of organic vegetables (n = 529)

Variables entered	Correlation	Estimate	Standardised beta	t-value	p-value
(Constant)		0.97		3.967	< 0.001
Less contaminants	0.572	0.428	0.387	10.698	< 0.001
More nutrients	0.538	0.281	0.363	10.775	< 0.001
No synthetic pesticide residues	0.435	0.103	0.121	3.341	0.001
Less mycotoxins	0.216	0.083	0.097	3.056	0.002

Variables not entered in the model: better controlled (r = 0.387), less micro-organisms (r = 0.120). Model goodness-of-fit: $R^2 = 48.6\%$

4.4 Discussion

4.4.1 Safety advantage of organic vegetables versus conventional vegetables

Statements:

1) “Organic vegetables contain less contaminants…”
2) “Organic vegetables contain no synthetic pesticide residues”

All foods, regardless of the production method, need to be ensured that they are sufficiently safe to be consumed. The question was whether the consumption of conventionally grown food provides any greater safety-related risks to consumers than organic food. Given the prohibition to use synthetic pesticides and synthetic fertilizers (containing nitrogen) in an organic farming system, it is reasonable to assume that organically grown food in general contain lower amounts of pesticide residues and nitrate.

Although in the international public literature, little data on pesticide residues in organic foods is available, scientific literature indicates that conventionally grown foods are more likely to contain (single and multiple) pesticide residues than organic foods. Furthermore, the residue levels in organic foods are consistently lower compared to conventional foods (Baker et al., 2002; Bitaud, 2000; Slanina, 1995; Woese et al., 1995, 1997). However, these findings do not mean that organic and conventional foods necessarily contain (detectable) amounts of pesticide residues (Fjelkner-Modig et al., 2000; Hajslova et al., 2005). Given these data, it can be concluded that consumers’ beliefs about the absence of residues of synthetic pesticides is to a large extent supported by scientific evidence. On the basis of the *Flemish* survey sample, a majority of the respondents (62 %) also agreed with the idea.

Another relatively consistent finding is that organic vegetables tend to have lower nitrate levels (Bourn & Prescott, 2002; Woese et al., 1995, 1997). The use of lower amounts and less available sources of nitrogen in organic farming (e.g. compost) is likely to be the underlying reason. For some vegetables with a lower nitrate accumulating capacity like seed and bulb vegetables, the fertilisation practices appear to have less influence on the nitrate content. Consequently, lower and equal amounts of nitrate between organic and conventional vegetables are reported in literature (Woese et al., 1997).

Less evidence exists concerning the relative content of heavy metals (e.g. cadmium, arsenic) between organic and conventional products. From the limited data available, no major differences are observed. Given equal possibilities for heavy metals to be absorbed in vegetables of organic and conventional production, no significant differences were expected. Cadmium could be an exception due to the use of sewage sludge in conventional farming, which could eventually lead to higher cadmium levels in conventional vegetables. However, no differences were detected for cadmium in the comparative studies evaluated for the two forms of cultivation (Jorhem & Slanina, 2000; Magkos et al., 2006; Malmauret et al., 2002; Woese et al., 1997).

Taking these facts into consideration in combination with the possibility that consumers have their own interpretation of the term “contaminant”, it is quite understandable that consumers perceived organic vegetables as being less contaminated compared to conventional vegetables ($\mu = 6.07$). Additionally, it appeared from the correlation and stepwise regression analyses that the contaminant content (relatively to the other attributes) was consumers’ most important food content-related motive for believing in the health advantage of organic vegetables ($r^2 = 0.327$).

<u>Statements:</u>

3) “Organic vegetables contain less harmful micro-organisms…”
4) “Organic vegetables contain less mycotoxins…”

The question of whether the consumption of organically grown vegetables causes any greater microbiological risk to consumers than conventional vegetables remains unclear. Several studies indicated higher bacterial contamination in organically versus conventionally grown crops, while others showed no difference (Avery, 1998; Johannessen et al., 2004; Mukherjee et al., 2004). Some authors have suggested that, given the use of animal manure and the prohibition of fungicides and some food additives in organic production practices, organically produced foods may have an increased risk of microbiological contamination (Avery, 1998; Stephenson, 1997). However, other research found that most pathogens were destroyed due to the high temperature during the composting period (Amlinger, 1993; Food Standards Agency, 2000).

Scientific evidence is currently insufficient to state that organically grown food is more prone to microbial or mycotoxin contamination than conventionally grown food. Although science is inconclusive in this matter, consumers' perception on both the statements of harmful micro-organisms and mycotoxins was in favour of organic vegetables with a mean perception score of about five ("slightly agree") on a 7-point Likert scale. In this case where science is more undecided, consumers were also less convinced. Specifically, 28.7% (micro-organisms) and 25.9% (mycotoxins) of the sample are also undecided (responding neutral on the 7-point Likert scale). The proportion of consumers scoring neutral was clearly lower for the other attributes, with the exception of the attribute "better controlled" (21.2%).

Statement:

5) "Organic vegetables are better controlled…"

A mean perception score of 5.22 was obtained for the statement that organic vegetables are better controlled than conventional vegetables. This indicates that consumers in general perceived organic vegetables to be more subject to quality and safety controls compared to conventional vegetables. From a scientific point of view however, it is not possible to draw a valid conclusion on that statement as no qualitative and quantitative data are available on the relative frequency and intensity of quality and safety controls of organic versus conventional vegetables.

4.4.2 Nutritional and health benefits of organic vegetables versus conventional vegetables

Statements:

6) "Organic vegetables contain more nutrients…"
7) "Organic vegetables are healthier…"

The results of the consumer survey suggest that consumers believed that organic vegetables are healthier than conventional vegetables, partly owing to their perceived nutrient content (e.g. vitamins and minerals). With the possible exception of vitamin C content, there is not enough scientific evidence that organic and conventional vegetables differ in nutritional value (Magkos et al., 2003a; Rembialkowska, 2007; Williamson, 2007; Woese et al., 1997). A large number of inconsistent results were observed from comparative studies in the literature. As it was the case for microbiological contamination, consumers overestimated the nutrient content of organic relative to conventional vegetables. About 60 % of the respondents scored 5 (“slightly agree”) or more (“totally agree”) on the 7-point Likert scale. Besides the nutrient content, another important motive for consumers to believe in the health benefits of organic vegetables was the lower contamination level of organic compared to conventional vegetables. From the correlation and regression analysis, it was apparent that consumers gave a higher credence to the health benefit of less contaminants than of more nutrients. This finding should come as no surprise, given that unfavourable communication related to food health issues weigh more heavily in consumers’ food consumption decisions than favourable news (Kinnucan et al., 1997; Robenstein & Thurman, 1996).

A summary of the results is provided in Table 4.6.

Table 4.6 Summary table

Item	Scientific evidence	Consumer perception
Healthier	inconclusive	organic > conventional
More nutrients	inconclusive	organic > conventional
Less contaminants	mostly in favour of organic	organic > conventional
No synthetic pesticide residues	organic > conventional	organic > conventional
Less harmful micro-organisms	inconclusive, but mostly in favour of conventional	organic > conventional
Less mycotoxins	inconclusive, but mostly in favour of conventional	organic > conventional
Better controlled	inconclusive	organic > conventional

4.5 Conclusions

Important gaps were observed between consumer perception and current scientific evidence concerning the nutritional value and safety of organic vegetables compared to conventional vegetables. Although current scientific literature cannot state that organically produced vegetables are superior to conventionally produced alternatives, consumers on average believed that organic vegetables are better. In other words, consumers in general seemed to overestimate the nutritional and safety benefits of organic vegetables, with the exception of synthetic pesticide residues. The gap between facts and consumers’ perceptions appeared to be the largest for the health character, nutritional value and microbiological safety of vegetables, especially among older consumers with children. The contaminant and nutrient content of organic vegetables were the two major drivers, among considered attributes, for consumers to believe in the health advantage of organic over conventional vegetables. The mismatch was also stronger when the consumption frequency was higher, but was independent of gender, place of residence, education and income level. Where science is more undecided, consumers' perception of organic versus conventional vegetables may be based on stereotypes, image transfer and emotion instead of factual knowledge and personal experience. In the future, more research is needed to strengthen scientific evidence about relative benefits and risks of organic compared to conventional vegetable consumption, as such that consumers can make decisions based on correct and objective information. Future research is also needed to verify the results of the present study that is based on a relatively small sample size and non-probability convenience sampling method, with larger and statistically representative consumer samples. An important basis for further research is now provided as new insights into basic beliefs and perceptions of a sample of *Flemish* consumers concerning organic versus conventional vegetables were generated here.

Managerial implications from this study mainly pertain to product positioning and communication strategies. The present study indicated that organic vegetables benefit from favourable consumer perceptions, some of which cannot be scientifically substantiated. From the perspective of the organic vegetable sector, it seems dangerous to exploit propositions that are not fully scientifically sound in their product positioning and communication strategies. A recommendation from this study would be to capitalise rather on emotional value than providing rational argumentation for the choice of organic vegetables. An opposite strategy could obviously be recommended to the conventional vegetable industry. Given the inconclusiveness of current scientific evidence, it is recommended from a public and health policy point of view, to further aim at stimulating vegetable consumption in general without differentiating between the eventual organic or conventional origin of the produce.

Chapter 5

Consuming organic versus conventional vegetables: The effect on nutrient and contaminant intakes

This chapter is based on:

Hoefkens, C., Sioen, I., Baert, K., De Meulenaer, B., De Henauw, S., Vandekinderen, I., Devlieghere, F., Opsomer, A., Verbeke, W., & Van Camp, J. (2010). Consuming organic versus conventional vegetables: the effect on nutrient and contaminant intakes. *Food and Chemical Toxicology, 48*(11), 3058-3066.

Abstract

The health benefits of consuming organic compared to conventional foods are unclear. This chapter aims at evaluating the nutrient and contaminant intake of adults through consumption of organic versus conventional vegetables, namely carrots, tomatoes, lettuce, spinach, and potatoes. A probabilistic simulation approach was used for the intake assessment in two adult populations: (1) a representative sample of Belgians (n = 3245) and (2) a sample of Flemish organic and conventional consumers (n = 529). Although significant differences in nutrient and contaminant contents were previously found between organic and conventional vegetables, the results were inconsistent for a component and/or vegetable. Also on the intake level the intake of specific nutrients and contaminants could be higher or lower for organic versus conventional vegetables. However, when considering the consumption pattern of organic consumers, an increase in intake of a selected set of nutrients and contaminants was observed, which was explained by the general higher vegetable consumption of this consumer group. In public health terms, there is insufficient evidence to recommend organic over conventional vegetables. The general higher vegetable consumption of organic compared to conventional consumers outweighed usually the role of differences in nutrient and contaminant concentrations between organic and conventional vegetables.

5.1 Introduction

The EU as well as national and regional governments support the organic agriculture and food sector. Some consumers are willing to pay an important premium for organic food (Bonti-Ankomah & Yiridoe, 2006; Mondelaers et al., 2009b). The question rises whether organic food and farming have an added value that justifies the support and the price premium.

For this reason the Flemish government financed a project aiming to compare organic and conventional food and agricultural systems from a point of view of environment friendliness (Mondelaers et al., 2009a), nutritional value and safety (de Backer et al., 2009; Hoefkens et al., 2009a). The research project was performed by a multidisciplinary team from Ghent University. The methodology implied a meta-analysis of the existing scientific literature. Meta-analyses are performed on the basis of available scientific evidence which is usually identified and compiled in a first phase by (systematic) reviews. Important reviews in the domain of food quality and safety issues of organic versus conventional foods are: Bourn and Prescott (2002), Brandt and Molgaard (2001), Dangour et al. (2009), Magkos et al. (2003a), Rembialkowska (2003), Woese et al. (1997), Worthington (2001). In general, the evidence provided with regard to the nutritional quality and safety aspects of studied vegetables (carrot, tomato, lettuce, spinach, potato) was inconclusive, especially about the nutritional value. For synthetic pesticide residues and nitrates significantly lower concentrations were generally found in the organic compared to conventional food. It is important to note that these observations relate to the evidence base available in 2009 with its limitations in the design and comparability of studies. Based on this evidence, the benefits to individuals consuming a diet of organic and/or conventional foods are unclear. In an attempt to evaluate the effect of concentration differences between organic and conventional foods on the nutrient and contaminant intake, it is also important to take the potential difference in consumption pattern between organic and conventional consumers into consideration. The aim of the present chapter is to evaluate the potential added value of the consumption of organic vegetables compared to conventional vegetables in terms of public health. Therefore, nutrient and contaminant intakes were assessed probabilistically and compared with respective recommendations. The choice to focus on vegetables is motivated first by their importance as a source of vitamins, minerals, dietary fibre and various beneficial phytochemicals, and second by their importance in the organic foods market in Belgium with a market share in 2009 of 29 % in terms of volume and a market penetration of 51% (provided by GfK Panelservices Benelux).

5.2 Methodology

5.2.1 Scenarios

The effect of consuming organically cultivated vegetables instead of conventional vegetables was evaluated in this chapter on the intake level. In Chapter 3 the comparison was made based on the nutrient and contaminant content of the vegetables only (Hoefkens et al., 2009a). A probabilistic simulation approach was applied, meaning that the variability and in some cases the uncertainty of the vegetable consumption, body weight (bw) and concentration data were considered and represented by distributions (parametric or non-parametric) instead of single values. Two consumption datasets using different intake assessment methods were used for scenario analyses. In the first scenario, which evaluated the effect of a potential difference in nutrient and contaminant content between organic and conventional produce on the intake, the method described by Sioen et al. (2008) was applied. This method uses the program ProbIntake^{UG} (developed at Ghent University, Belgium) which is a software module applicable in the free available software R® (R Development Core Team, Vienna, Austria). Scenario 1, further referred to as the *Concentration effect scenario*, assumed that consumers of organic and conventional vegetables have a similar vegetable consumption pattern. The assumption was dismissed in the second scenario where on top of a content difference the influence of a possible dissimilarity in vegetable consumption pattern between organic and conventional consumers was evaluated on the intake of nutrients and contaminants (further referred to as the *Consumption effect scenario*). To execute this simulation, the method described by Baert et al. (2007) using @Risk 4.5 (Palisade Corporation, Newfield, NY, USA) was applied. Compared to the previous method, this method enables uncertainty assessment of the intake, which seemed advisable, as for scenario 2 not only the concentration data were characterised by uncertainty but also the consumption data. Five hundred bootstrap iterations were performed to estimate the 95% confidence interval (CI) to describe the uncertainty of the intake assessments. Both methodologies calculated the intake by multiplying consumption data (as a function of time (days) and body weight (kg)) with nutrient or contaminant concentration data of organic and conventional vegetables.

5.2.2 Food consumption data

Two different food consumption databases were used, one in each scenario. The *concentration effect scenario* was based on the vegetable consumption data from the Belgian national food consumption survey 2004 (Debacker et al., 2007). From these data, it is clear that the Belgian population does not consume enough vegetables a day with an average of 138 g compared to the daily recommended amount of 350 g. Aims, design and methods of the national food consumption survey are described elsewhere (De Vriese et al., 2005). Briefly, a total of 3245 adults were asked to report all their consumptions of the preceding day during two non-consecutive 24-h recalls interviews and to complete a food frequency questionnaire (FFQ). A total of 3083 respondents completed two 24-h recalls of which 1546 men and 1537 women of 15 years or older. Only the data of the individuals who completed two 24-h recalls were used in this study. The data from the FFQ were not used.

The food consumption database used in the consumption effect scenario was collected from 529 adults aged between 18 and 84 years through a FFQ during the period of December 2006 - February 2007 in Flanders (the northern, Dutch speaking part of Belgium) (Van Huylenbroeck et al., 2009). Seven individuals were removed from the sample because of incomplete information, leaving a final sample of 522 valid cases (243 men and 279 women). This FFQ was part of a larger questionnaire on perceptions and attitudes of organic consumers (Hoefkens et al., 2009b). The FFQ assessed the frequency and the amount of consumption of the organic versus conventional vegetables, namely carrot, tomato, lettuce, spinach, and potato. Half of the sample comprised members (n = 266) of the Flemish organisation VELT that promotes an ecological lifestyle. These VELT members were considered to be more highly involved in organic food. This selection was informed by our interest in comparing organic with conventional consumers. The non-VELT members were recruited by means of a non-probability convenience sampling.

For the purpose of the study, an organic consumer of a specific food item was defined as an individual consuming only the organic variant of the considered vegetable, whereas a conventional consumer was considered someone who only eats vegetables produced through non-organic farming. Medium and low users of organic vegetables, i.e. consumers of both organic and conventional vegetables, were excluded in this study. For example, an individual stating to consume only organic tomatoes (no conventional tomatoes) was defined as an organic tomato consumer.

5.2.3 Nutrient and contaminant data

The classes of nutrients and contaminants included in the present study were vitamins and pro-vitamins (vitamin C, carotenoids: β-carotene, lycopene, lutein), minerals (potassium, calcium), secondary plant metabolites other than carotenoids (chlorogenic acid, glycoalkaloids), nitrate, heavy metals (cadmium, lead) and pesticides (iprodion, chlorothalonil, chloropropham). The selection of the compounds was based on the results obtained in Chapter 3 and motivated by the aim of evaluating the implications of these significant concentration differences with regard to public health. The various vegetable-compound combinations being studied in the two scenarios are described in the results section.

The nutrient and contamination data used in this study originated from two newly developed databases compiled from internationally available secondary data. The compilation procedure, including data collection, data documentation, data evaluation and selection, and data weighing, has been described in Chapter 3. In total, 39 and 35 relevant sources of respectively nutrient and contaminant data for the selected vegetables were entered in the databases (a list of references is included in Appendix I).

5.2.4 Evaluation of nutrient and contaminant intakes

The evaluation of the intake assessments comprised a comparison with the dietary reference intake (DRI) for the nutrients and the tolerable daily intake (TDI) in the case of the contaminants, except for pesticide residues for which an acceptable daily intake (ADI) is set. As the obtained nutrient and contaminant intakes were expressed per kg bw, “ad hoc” reference values had to be calculated taking a mean body weight of 70 kg of both adult populations into account. For vitamin C, the DRI formulated by the Belgian Health Council (2009) amounts 110 mg/day, leading to a reference value of 1.57 mg/kg bw/day. To date, no recommended dietary intake level has been established for β-carotene. However, the National Academy of Sciences supports the recommendations of various health agencies, which encourage consumers to eat at least five servings of fruits and vegetables a day. This level of consumption of fruits and vegetables provides approximately three to six milligrams of β-carotene (Institute of Medicine, 2001). Therefore, a preliminary reference value of 3 mg β-carotene/day or 43 µg/kg bw/day was considered for further evaluation. For potassium and calcium, the Belgian DRI is 3000 à 4000 mg/day (applied in this approach as 43 mg/kg bw/day) and 900 mg/day (applied in this approach as 13 mg/kg bw/day), respectively. With regard to the secondary plant metabolites, no recommendation currently exists. To our knowledge, the no observed adverse effect level and TDI for glycoalkaloids have also not been set yet. Temporarily, a potato-based dose of 1 mg/kg bw/day is considered as preliminary minimal critical exposure dose for humans (JECFA, 1993b; Ruprich et al., 2009). The (provisional) thresholds or TDIs (ADIs) used to evaluate the contaminants in the present study are: 3.7 mg/kg bw/day for nitrate (Heppner et al., 2008; JECFA, 2003), 0.36 µg/kg bw/day for cadmium (2.5 µg/kg bw/week) (Heppner et al., 2009), 3.6 µg/kg bw/day for lead (JECFA, 1993a), 60 µg/kg bw/day for iprodion, 20 µg/kg bw/day for chlorothalonil and 50 µg/kg bw/day for chloropropham (JMPR, 2009).

Statistical analyses were performed using SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA). The non-parametric Mann-Whitney U-test was applied for comparing the median nutrient and contaminant intakes through organic vegetable consumption with the corresponding intake through conventional vegetable consumption. A chi-square test or Fisher’s exact test were applied to assess the significance of any relations between organic or conventional consumption on the one hand and socio-demographic characteristics and the consumption amount of vegetables on the other hand. Significance was assessed at $\alpha = 0.01$.

5.3 Results

5.3.1 Comparison of the vegetable consumption pattern

Based on the FFQ conducted in Flanders with the purpose to compare the consumption of organic food with the conventional alternative, a demographic profiling of the organic and conventional consumer was performed, which is shown in Table 5.1. The numbers were calculated on the sample of consumers eating only the organic respectively conventional variant of all considered vegetables (5 in total). The results showed that consumers of organic compared to conventional vegetables were more likely to be older ($p = 0.002$, chi-square test) and to have children in the household ($p = 0.005$, Fisher’s exact test). No relation was found between organic consumption and gender, education and income ($p > 0.01$, chi-square test). Next to differences in demographic characteristics, some important findings were identified with regard to the amount of vegetables consumed between both types of consumers. Organic consumers had significant larger portion sizes of carrot, tomato, lettuce and potato ($p < 0.001$, Mann-Whitney U-test). The consumed amount of spinach was similar for organic and conventional consumers (Table 5.1).

Table 5.1 Profiling of organic and conventional consumers by demographic characteristics and vegetable consumption (Van Huylenbroeck et al., 2009)

Considered per individual vegetable		Organic consumer	Conventional consumer
Vegetable consumption			
Carrot	n	177	102
	grams/day	49 [0-353]	32 [0-233]
Tomato	n	109	105
	grams/day	70 [0-425]	56 [0-456]
Lettuce	n	142	82
	grams/day	16 [0-70]	8 [0-70]
Spinach	n	94	84
	grams/day	32 [0-403]	30 [0-403]
Potato	n	150	167
	grams/day	110 [0-491]	101 [0-491]

Considered per total vegetables		Organic consumer	Conventional consumer
Socio-demographics	n	55	58
Gender	Male	60	41
	Female	40	59
Age	18-35	5	31
	36-45	24	24
	46-55	31	28
	55+	40	17
Children in the household	Yes	87	64
	No	13	36
Education	Secondary	60	43
	Higher	40	57
Family income	< 1500 €/month	31	50
	1500-2000 €/month	23	25
	2000-2500 €/month	25	14
	> 2500 €/month	21	11

5.3.2 Comparison of nutrient and contaminant intakes through vegetable consumption

In Chapter 3 significant higher concentrations of *vitamin C* were found in organic tomato, but significantly lower concentrations in organic carrots and potatoes compared to the conventional alternative. For all vegetables except for lettuce, the concentration of *β-carotene* was significantly higher in the organically grown vegetable when comparing the organic and conventional vegetable. With regard to the *secondary plant metabolites* studied (other than β-carotene), the organic vegetables contained a significantly lower content compared the conventional product except for potato. In the case of the *minerals* calcium and potassium, also inconsistent results were obtained when comparing the organic and conventional vegetables. Also no trend was found considering the heavy metals cadmium and lead. Given the prohibition of using synthetic pesticides and synthetic fertilizers (containing nitrogen) in organic farming systems, it was of no surprise to find significantly lower concentrations of synthetic pesticide residues and nitrates in the organically grown vegetables compared to the conventionally grown vegetables with the exception of nitrate in spinach.

Within the purpose of this study, the above results were translated in terms of public health through the combination with consumption data. The estimated intake assessments obtained using the Belgian consumption survey data (*Concentration effect scenario*) are summarised in Table 5.2 for the nutrients and Table 5.3 for the contaminants. The results are provided for the total study sample, including the non-consumers, and for two situations: (1) assuming that all vegetables consumed were conventionally grown vegetables and (2) assuming that all vegetables consumed were organically grown vegetables. The number of non-consumers for this scenario is equal for both the organic and conventional intake distributions which forms the basis for comparison of the results.

The primer implication with regard to public health of previously found significant concentration differences was the higher probability of achieving and even exceeding the preliminary DRI of β-carotene and this by considering the intake through one single organically grown vegetable. About 20%, 1% and < 5% of the Belgian adults consuming respectively organic carrots, tomatoes and spinach had an intake of β-carotene higher than the corresponding preliminary reference value while for conventional carrots, tomatoes and spinach, this was respectively 16%, < 1% and 3%. The minor, although statistically significant differences in mineral concentrations between organic and conventional tomato were removed in the case of potassium and changed in advantage for calcium when assessing the intake of both compounds. The low consumption level of spinach in the Belgian adult population led to similar nutrient intakes through organic and conventional consumption, although a significantly different nutrient composition was found earlier. The results for scenario 1 of the other studied vegetable-nutrient combinations are shown in Table 5.2 but are not discussed here as its concentration differences remained on intake level as expected without exceeding the corresponding DRI. For the contaminants, the intake assessments through organic and conventional vegetable consumption were all below the TDI or ADI. Previously observed small differences in contaminant concentrations disappeared after being combined with the consumption data for intake assessments (cadmium from carrot and lettuce; nitrate, cadmium and lead from spinach).

Table 5.2 Concentration effect scenario: Summary of the simulation results of the nutrient intake assessment through consumption of organic (O) versus conventional (C) vegetables for a representative sample of Belgian adults (Debacker et al., 2007)

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Vitamin C (mg/kg bw/day)	P50	0.003	0.003	0.040	0.037	-	-	-	-	0.112	0.226
	P90	0.027	0.031	0.271	0.251					0.265	0.538
	P95	0.042	0.049	0.366	0.340					0.320	0.645
	P97.5	0.058	0.066	0.457	0.424					0.371	0.749
	P99	0.083	0.095	0.572	0.533					0.451	0.922
	Mean	0.009	0.011	0.096	0.089					0.129	0.260
β-carotene (µg/kg bw/day)	P50	10	8	3	2	-	-	0	0	-	-
	P90	**89**	**70**	20	17			0	0		
	P95	**140**	**110**	27	23			38	21		
	P97.5	**188**	**147**	34	29			**79**	**45**		
	P99	**268**	**212**	**43**	39			**120**	**69**		
	Mean	30	24	7	6			5	3		
Lycopene (µg/kg bw/day)	P50	-	-	4	18	-	-	-	-	-	-
	P90			32	129						
	P95			44	175						
	P97.5			56	223						
	P99			74	288						
	Mean			11	45						
Lutein (µg/kg bw/day)	P50	-	-	-	-	0.00	0.00	0	0	-	-
	P90					1.91	2.24	0	0		
	P95					2.72	3.20	30	42		
	P97.5					3.82	4.50	62	86		
	P99					5.36	6.23	94	131		
	Mean					0.53	0.62	4	5		
Potassium (mg/kg bw/day)	P50	0.17	0.22	0.62	0.61	0.00	0.00	-	-	5	6
	P90	1.51	1.98	4.15	4.11	1.60	0.58			12	14
	P95	2.37	3.11	5.65	5.57	2.29	0.84			14	17
	P97.5	3.15	4.17	7.02	6.96	3.18	1.16			16	20
	P99	4.53	5.96	8.84	8.72	4.44	1.66			20	24
	Mean	0.51	0.67	1.48	1.46	0.44	0.16			6	7

Continued

Notes: "-" indicates that for the specific nutrient-vegetable combination no data were available to simulate the intake; the intakes higher than the reference value for that nutrient are indicated in bold, the reference values are based on the DRIs proposed by the Belgian Health Council or the Institute of Medicine, but are expressed as a function of body weight (for explanation see text)

Table 5.2 Continued

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Calcium (mg/kg bw/day)	P50	-	-	0.021	0.020	0.000	0.000	-	-	0.057	0.147
	P90			0.144	0.136	0.202	0.084			0.133	0.352
	P95			0.196	0.183	0.307	0.122			0.161	0.430
	P97.5			0.247	0.230	0.438	0.168			0.187	0.505
	P99			0.317	0.293	0.631	0.239			0.227	0.612
	Mean			0.051	0.048	0.057	0.023			0.065	0.170
Chlorogenic acid (µg/kg bw/day)	P50	-	-	-	-	-	-	-	-	310	234
	P90									729	547
	P95									875	658
	P97.5									1003	758
	P99									1225	925
	Mean									354	266
Glycoalkaloids (µg/kg bw/day)	P50	-	-	-	-	-	-	-	-	116	90
	P90									273	211
	P95									329	254
	P97.5									382	296
	P99									463	359
	Mean									133	102

Notes: "-" indicates that for the specific nutrient-vegetable combination no data were available to simulate the intake; the intakes higher than the reference value for that nutrient are indicated in bold, the reference values are based on the DRIs proposed by the Belgian Health Council or the Institute of Medicine, but are expressed as a function of body weight (for explanation see text)

Table 5.3 Concentration effect scenario: Summary of the simulation results of the contaminant intake assessment through consumption of organic (O) versus conventional (C) vegetables for a representative sample of Belgian adults (Debacker et al., 2007)

		Carrot		Tomato		Lettuce		Spinach		Potato	
		O	C	O	C	O	C	O	C	O	C
Nitrate (mg/kg bw/day)	P50	0.015	0.012	-	-	0.000	0.000	0.000	0.000	0.203	0.262
	P90	0.145	0.114			0.363	0.612	0.000	0.000	0.480	0.609
	P95	0.233	0.178			0.538	0.879	0.777	0.747	0.581	0.733
	P97.5	0.324	0.237			0.747	1.230	1.620	1.603	0.673	0.840
	P99	0.473	0.339			1.054	1.747	2.489	2.462	0.810	1.036
	Mean	0.050	0.038			0.101	0.168	0.100	0.099	0.233	0.297
Cadmium (µg/kg bw/day)	P50	0.002	0.002	-	-	0.000	0.000	0.000	0.000	0.034	0.049
	P90	0.015	0.016			0.006	0.007	0.000	0.000	0.079	0.116
	P95	0.024	0.025			0.008	0.010	0.042	0.019	0.095	0.141
	P97.5	0.033	0.034			0.012	0.013	0.086	0.042	0.109	0.166
	P99	0.047	0.050			0.016	0.019	0.132	0.066	0.133	0.199
	Mean	0.005	0.005			0.002	0.002	0.005	0.003	0.039	0.056
Lead (µg/kg bw/day)	P50	0.006	0.004	-	-	-	-	0.000	0.000	0.101	0.126
	P90	0.066	0.045					0.000	0.000	0.242	0.334
	P95	0.108	0.076					0.031	0.023	0.294	0.419
	P97.5	0.161	0.108					0.064	0.070	0.344	0.508
	P99	0.232	0.161					0.096	0.134	0.412	0.626
	Mean	0.023	0.016					0.004	0.005	0.117	0.155
Iprodion (µg/kg bw/day)	P50	0.000	0.001	0.000	0.008	0.000	0.000	-	-	-	-
	P90	0.001	0.008	0.019	0.061	0.000	0.031				
	P95	0.001	0.014	0.028	0.082	0.000	0.112				
	P97.5	0.003	0.022	0.037	0.105	0.000	0.303				
	P99	0.005	0.034	0.051	0.138	0.000	0.840				
	Mean	0.000	0.003	0.006	0.021	0.000	0.035				
Chlorothalonil (µg/kg bw/day)	P50	-	-	0.000	0.001	-	-	-	-	-	-
	P90			0.008	0.016						
	P95			0.012	0.024						
	P97.5			0.018	0.034						
	P99			0.024	0.052						
	Mean			0.002	0.006						
Chloropropham (µg/kg bw/day)	P50	-	-	-	-	-	-	-	-	0.082	2.32
	P90									0.293	7.26
	P95									0.384	9.42
	P97.5									0.483	11.6
	P99									0.616	14.8
	Mean									0.121	3.16

Notes: "-" indicates that for the specific contaminant-vegetable combination no data were available to simulate the intake; the intakes exceeding the TDI (or ADI for pesticide residues) for that contaminant are indicated in bold, for the choice of the TDI or ADI see text

The results of the *Consumption effect scenario* considering the effect of the higher vegetable consumption of organic consumers except for spinach, as stated above, in addition to concentration differences between organic and conventional vegetables on the intake are presented in Table 5.4 for the nutrients and Table 5.5 for the contaminants. The selection of cases for this simulation was based on the significance of concentration differences of the considered nutrients and contaminants for the different vegetables and the relative relevance of a specific compound for these foods. Comparing the percentage of the consumers reaching the preliminary reference value for β-carotene, it was found that between 33% and 44% (with 95% certainty) of the organic consumers with their significantly higher consumption of carrots exceeded the recommendation compared to 19 to 26% of the conventional carrot consumers, without considering the intake from other vegetables. Although higher vitamin C intakes were observed for organic compared to conventional tomato, their CI overlapped, which indicates that the intake of vitamin C was roughly independent of the fact that the consumed tomatoes were organically or conventionally cultivated ($p = 0.111$, Mann-Whitney U-test). With regard to lycopene, the significantly higher tomato consumption of organic consumers seemed to compensate the significantly higher lycopene content of conventional tomatoes resulting in similar lycopene intakes ($p = 0.192$, Mann-Whitney U-test). The most significant difference in consumption level between organic and conventional consumers was found for lettuce resulting in significantly higher intakes of lutein and calcium from lettuce ($p < 0.001$, Mann-Whitney U-test). This means that for lutein the consumed amount of lettuce had more implications for public health than its content present in lettuce. In contrast with this, the concentration differences for vitamin C, chlorogenic acid and glycoalkaloids in potatoes were more significant compared to the difference in consumption level between organic and conventional consumers, as such that the nutritional composition of potatoes was more important than the amount consumed. The assessed contaminant intake results for this scenario indicated that the TDI or ADI was not exceeded, except for nitrate through consumption of organic lettuce. The significantly higher lettuce consumption of organic consumers led to higher nitrate intakes compared to conventional consumers, although organic lettuce was less contaminated with nitrate ($p < 0.001$, Mann-Whitney U-test). Table 5.5 shows that it is 95% certain that between 1% and 4 % of the organic consumers exceeded the TDI of nitrate. Significantly higher pesticide intakes through conventional vegetable consumption were still observed regardless the significantly higher vegetable consumption of organic consumers ($p < 0.001$, Mann-Whitney U-test). The higher lead contamination of organic carrots and the higher carrot consumption levels of organic consumers resulted in significantly higher intakes of lead for organic compared to conventional consumers ($p < 0.001$, Mann-Whitney U-test). Although higher concentrations of cadmium were observed in conventional potato, organic consumers were similarly exposed to this heavy metal compared to conventional consumers of potato ($p = 0.975$, Mann-Whitney U-test).

Table 5.4 Consumption effect scenario: Summary of the simulation results of the nutrient intake assessment through consumption of organic (O) versus conventional (C) vegetables for a convenience sample of Flemish adults, i.e. organic and conventional consumers only (Van Huylenbroeck et al., 2009)

		Carrot		Tomato		Lettuce		Potato	
		O	C	O	C	O	C	O	C
Vitamin C	P50	-	-	0 [0-0]	0 [0-0]	-	-	0.064 [0.050-0.099]	0.175 [0.153-0.204]
(mg/kg bw/day)	P90			0.456 [0.429-0.494]	0.373 [0.342-0.400]			0.382 [0.298-0.435]	0.515 [0.481-0.559]
	P95			0.651 [0.594-0.690]	0.470 [0.426-0.516]			0.466 [0.411-0.519]	0.604 [0.569-0.665]
	P97.5			0.725 [0.683-0.792]	0.582 [0.501-0.636]			0.534 [0.466-0.651]	0.704 [0.634-0.808]
	P99			0.832 [0.740-0.912]	0.704 [0.598-0.809]			0.663 [0.517-0.819]	0.866 [0.725-1.010]
	Mean			0.160 [0.153-0.166]	0.116 [0.109-0.123]			0.133 [0.115-0.152]	0.215 [0.201-0.230]
Carotenoids		β-carotene		Lycopene		Lutein		-	-
with provitamin A activity	P50	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]		
(µg/kg bw/day)	P90	**292 [254-328]**	**166 [133-203]**	38 [31-52]	28 [26-29]	5.89 [5.42-6.42]	3.48 [2.89-4.14]		
	P95	**362 [322-416]**	**232 [202-289]**	68 [47-93]	35 [31-40]	7.32 [6.53-7.90]	5.34 [4.37-6.37]		
	P97.5	**441 [371-497]**	**302 [237-372]**	96 [66-140]	42 [37-47]	8.33 [7.42-9.04]	6.72 [5.59-7.95]		
	P99	**503 [438-595]**	**380 [290-436]**	142 [90-191]	53 [44-61]	9.14 [8.40-9.67]	7.81 [6.54-11.73]		
	Mean	**88 [74-103]**	42 [35-50]	14 [12-18]	8 [8-9]	1.59 [1.49-1.70]	0.81 [0.68-0.96]		
Calcium	P50	-	-	-	-	0 [0-0]	0 [0-0]	-	-
(mg/kg bw/day)	P90					0.59 [0.48-0.80]	0.11 [0.09-0.15]		
	P95					1.07 [0.69-1.39]	0.17 [0.15-0.24]		
	P97.5					1.44 [1.14-1.86]	0.25 [0.17-0.35]		
	P99					1.87 [1.44-2.32]	0.34 [0.22-0.44]		
	Mean					0.18 [0.14-0.22]	0.03 [0.02-0.04]		
Chlorogenic acid	P50	-	-	-	-	-	-	242 [208-280]	143 [131-162]
(µg/kg bw/day)	P90							655 [604-707]	372 [345-404]
	P95							749 [701-869]	446 [408-492]
	P97.5							920 [781-1006]	513 [463-587]
	P99							1070 [922-1261]	623 [524-750]
	Mean							279 [258-300]	161 [150-170]
Glycoalkaloids	P50	-	-	-	-	-	-	89 [83-96]	55 [53-59]
(µg/kg bw/day)	P90							206 [191-222]	118 [112-126]
	P95							219 [250-269]	139 [129-155]
	P97.5							285 [258-326]	164 [149-186]
	P99							337 [288-412]	192 [171-229]
	Mean							93 [87-98]	54 [52-56]

Notes: "-" indicates that for the specific nutrient-vegetable combination no data were available to simulate the intake; the intakes higher than the reference value for that nutrient are indicated in bold, the reference values are based on the DRIs proposed by the Belgian Health Council or the Institute of Medicine (IOM), but are expressed as a function of body weight (for explanation see text)

Table 5.5 Consumption effect scenario: Summary of the simulation results of the contaminant intake assessment through consumption of organic (O) versus conventional (C) vegetables for a convenience sample of Flemish adults, i.e. organic and conventional consumers only (Van Huylenbroeck et al., 2009)

		Carrot		Tomato		Lettuce		Potato	
		O	C	O	C	O	C	O	C
Nitrate	P50	-	-	-	-	0 [0-0]	0 [0-0]	-	-
(mg/kg bw/day)	P90					1.85 [1.56-2.39]	0.86 [0.68-1.11]		
	P95					3.00 [2.15-3.47]	1.38 [1.10-1.75]		
	P97.5					3.59 [3.01-**3.88**]	1.97 [1.40-2.38]		
	P99					**3.89 [3.59-4.43]**	2.39 [1.86-2.89]		
	Mean					0.56 [0.48-0.63]	0.22 [0.18-0.25]		
Heavy metals:		Lead		-	-	-	-	Cadmium	
(µg/kg bw/day)	P50	0 [0-0]	0 [0-0]					0.030 [0.026-0.035]	0.028 [0.024-0.031]
	P90	0.845 [0.644-1.075]	0.140 [0.060-0.250]					0.089 [0.078-0.098]	0.109 [0.091-0.128]
	P95	1.294 [1.060-1.468]	0.392 [0.191-0.668]					0.107 [0.096-0.118]	0.152 [0.126-0.175]
	P97.5	1.612 [1.362-1.883]	0.687 [0.381-1.100]					0.124 [0.108-0.149]	0.187 [0.156-0.222]
	P99	1.959 [1.666-2.218]	1.081 [0.611-1.412]					0.152 [0.123-0.190]	0.229 [0.186-0.310]
	Mean	0.194 [0.148-0.241]	0.061 [0.038-0.088]					0.036 [0.034-0.039]	0.042 [0.037-0.046]
Iprodion	P50	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	0 [0-0]	-	-
(µg/kg bw/day)	P90	0 [0-0]	0.015 [0.010-0.025]	0.000 [0.000-0.064]	0.041 [0.025-0.078]	0 [0-0]	0.000 [0.000-0.001]		
	P95	0 [0-0]	0.032 [0.020-0.051]	0.072 [0.000-0.161]	0.120 [0.063-0.204]	0 [0-0]	0.004 [0.002-0.007]		
	P97.5	0.000 [0.000-0.013]	0.054 [0.031-0.093]	0.156 [0.000-0.231]	0.216 [0.123-0.302]	0 [0-0]	0.009 [0.005-0.056]		
	P99	0.001 [0.000-0.083]	0.086 [0.046-0.201]	0.235 [0.123-0.326]	0.322 [0.204-0.553]	0 [0-0]	0.098 [0.011-0.927]		
	Mean	0.000 [0.000-0.001]	0.006 [0.004-0.018]	0.010 [0.003-0.019]	0.021 [0.014-0.035]	0 [0-0]	0.010 [0.001-0.055]		
Chlorothalonil	P50	-	-	0 [0-0]	0 [0-0]	-	-	-	-
(mg/kg bw/day)	P90			0 [0-0]	0.015 [0.012-0.022]				
	P95			0.000 [0.000-0.047]	0.036 [0.020-0.058]				
	P97.5			0.000 [0.000-0.160]	0.061 [0.038-0.095]				
	P99			0.132 [0.000-0.283]	0.101 [0.059-0.267]				
	Mean			0.003 [0.000-0.010]	0.008 [0.005-0.021]				
Chloropropham	P50	-	-	-	-	-	-	0 [0-0]	0 [0-0]
(µg/kg bw/day)	P90							0.264 [0.078-0.834]	6.72 [5.04-8.69]
	P95							0.967 [0.280-1.826]	10.98 [8.36-13.93]
	P97.5							1.727 [0.515-2.846]	15.3 [11.6-20.7]
	P99							2.60 [1.24-3.87]	21.5 [15.0-31.9]
	Mean							0.142 [0.068-0.247]	1.97 [1.52-2.49]

Notes: "-" indicates that for the specific contaminant-vegetable combination no data were available to simulate the intake; the intakes exceeding the TDI (or ADI for pesticide residues) for that contaminant are indicated in bold, for the choice of the TDI or ADI see text

5.4 Discussion and conclusions

In this chapter, differences in nutrient and contaminant intake through the consumption of organic and conventional vegetables and their possible implications for public health were evaluated. Previously, vegetable composition databases were developed based on secondary data to quantify nutrient and contaminant concentrations and their variability in organic and conventional vegetables. The problems encountered during the compilation of these databases and potential solutions were discussed in Chapter 3, but one of them is repeated here as it is relevant for the interpretation of the results of the present study. It concerns the difficulty in differentiating whether a difference in composition between organic and conventional vegetables, possibly leading to a difference in nutrient and/or contaminant intake between organic and conventional consumers, is due to the cultivation method itself (organic versus conventional) or due to one or more other factors such as the variety, soil type, storage conditions post harvest, or supply chain differences. Additional limitations and assets related to the consumption databases as well as to the approaches used for intake assessments are discussed here.

First, two different food consumption databases collected by different methodologies have been used, i.e. two non-consecutive 24-h recalls versus a FFQ asking the frequency of eating the organically versus conventionally cultivated variant of the vegetable. Also the period (2004 versus 2006/2007) and the geographical coverage (Belgium versus Flanders) of both consumption surveys were different. Despite the advantage of a representative nationwide sample, the national consumption survey has an important limitation with a view on the purpose of this study because of missing information about the cultivation method of the vegetables consumed. Another limitation of the national food consumption survey is the short-term character of the collected data due to the limited number of consumption days registered per person. Several statistical methods such as the Nusser method are proposed in literature to estimate long-term or usual intakes by eliminating the so-called intra-individual or within person variability (Hoffmann et al., 2002). These methods were not applied here as, firstly, the improvement in accuracy was considered to be small relative to other sources of within-person or day-to-day variability and secondly, the main purpose of the study was to evaluate the intake through organic consumption compared to intakes from conventional vegetable consumption and not to estimate nutrient and contaminant intakes as such. Moreover, applying the Nusser method is also difficult when a high proportion of non-consumers is present in the database. From a public health point of view, the lack of national consumption data of children posed an important limitation to this study as children are at higher risk of having high contaminant intakes per kg bw due to higher amounts of food consumed when expressed per kg bw (Kroes et al., 2002).

Considering the intake distribution estimated in this study, two different probabilistic approaches were used to combine each consumption database with the nutrient and contaminant content database depending on the effect to be estimated on the intake, i.e. the effect of concentration differences between organic and conventional vegetables on the intake (cf. Concentration effect scenario) and the combined effect of concentration differences and different consumption patterns of organic versus conventional consumers (cf. Consumption effect scenario). The advantage of using a probabilistic approach is that the distribution of the consumption as well as of the nutrient and contaminant concentration can be taken into account, resulting in a distribution of the intakes. It should, however, be emphasised that the distribution functions for most nutrients and contaminants in organic vegetables were extrapolated from a relatively small amount of data (cf. Chapter 3). For the distributions expressing the estimated nutrient and contaminant intakes, a very skewed distribution was found in most cases (illustrated by a high difference between the mean and the median value), due to the presence of non-consumers and infrequent consumption of some vegetables. The approach of Baert et al. (2007) enabling variability and uncertainty assessment of the intake, was favoured for the second scenario as for this simulation both the consumption and concentration data were characterised by uncertainty. The method of Sioen et al. (2008) was used for the first scenario where the uncertainty assessment was considered to be less important as this simulation aimed at evaluating the nutrient and contaminant intake assessments against respectively the DRI and TDI. Finally, it is important to note that these thresholds are referring to intakes from the total diet and not from specific food items such as individual vegetables. A similar assessment considering the intake from other organic and conventional dietary sources is recommended for further research.

Attempts to profile consumers of organic foods by demographic characteristics yielded a mixed picture, especially by income and educational level. However, some consistencies are observed across research studies with regard to the gender, presence of children and age (Hughner et al., 2007). Organic consumers are described as older women having children in the household. The results of the demographic profiling of this study support the relation between organic consumption and, age and the presence of children, not gender. For education and income neither a positive nor a negative relationship was found. Important to note is that the definition of organic consumers across studies might be different. In this study it was based on the reported proportion of consumption of the considered organic relative to conventional vegetables. Moreover, medium and low users of organic vegetables were even excluded in the intake simulations in order to obtain clearer insights into the potential impact of organic versus conventional vegetable consumption on nutrient and contaminant intakes. Furthermore, considerable confusion surrounding the term ‘organic’ exists among consumers (Chryssochoidis, 2000). The significant higher consumption of vegetables in the group of organic consumers is also in line with research findings stating that organic food consumption is associated with vegetarianism, active environmentalism, alternative medicine and/or preventative health actions (through diet) (Cicia et al., 2002; Makatouni, 2002).

To date a large number of studies have been conducted investigating differences in nutritional quality and safety between organically and conventionally produced foods. However, the number of studies being of satisfactory quality is disappointingly low according to the latest review (Dangour et al., 2009). In contrast, studies investigating the effect of organic food consumption on animal and human health are scarce. Few studies have shown some differences in effect of organic and conventional feed or diet on the immune status (Finamore et al., 2004; Lauridsen et al., 2005), reproductive health, growth and weight development (Williams, 2002), and the plasma antioxidant status (Di Renzo et al., 2007; Grinder-Pedersen et al., 2003; Stracke et al., 2009). However, much more controlled clinical human trials will be needed to further investigate health impacts of organic versus conventional diets on human health.

In conclusion, the intake of nutrients and contaminants through both organic and conventional vegetable consumption in a sample of Belgian and Flemish adults did not imply any public health concerns except for nitrate through the consumption of organic lettuce in a small percentage of the population (between 1% and 4%, 95% CI). An average nitrate intake through organic lettuce of 0.56 mg/kg bw/day [95% CI 0.48-0.63 mg/kg bw/day] was estimated. This result is in line with the average intake estimates of two studies that used a deterministic approach, i.e. 0.32 mg/kg bw/day (De Martin & Restani, 2003) and 0.39 mg/kg bw/day (Guadagnin et al., 2005) from lettuce. This nitrate concern has also been raised by the European Food Safety Authority's Contaminants Panel who assessed the risks and benefits to consumers from nitrates in vegetables. The Panel concluded that the beneficial effects of eating vegetables and fruit outweigh potential risk to human health from exposure to nitrate through vegetables (Heppner et al., 2008). It should also be emphasised that the obtained figures have to be interpreted with caution as the vegetable consumption was determined by self-report and may be an overestimation of the actual consumption. A more important finding was the general higher vegetable consumption of organic compared to conventional consumers, which outweighed in most cases the role of differences in nutrient and contaminant concentrations between organic and conventional vegetables. If the beneficial effects of vegetables are to be enhanced for the general population, emphasis will have to be laid on food choice education instead of on the farming system by which the vegetables are produced.

PART III

Case study 2: Nutrition information on university canteen meals

Part III of this doctoral dissertation (Chapters 6 to 8) covers the second case study which deals with the role of point-of-purchase (POP) nutrition information in university canteens in consumers' meal choice and nutrient intake. The purpose of Part III is twofold. First, the effectiveness of POP nutrition information in improving canteen customers' meal choice and nutrient intake is evaluated and explained. The results of the main effect of this nutrition-information intervention study are reported in Chapter 6 (Study 4). Chapter 7 builds further on the intervention effect observed in Chapter 6 by investigating the process by which the nutrition information achieved its effects on the meal choice and energy intake in subgroups of consumers. The second objective of Part III is to identify and understand consumers' preferences for alternative nutrition label formats for use in university canteens as an additional explanation for the effectiveness of nutrition information in university canteens. This objective is dealt with in Chapter 8 reporting the results of the choice experiment (Study 5).

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Chapter 6

The effect of posting point-of-purchase nutrition information in university canteens on the meal choice and nutrient intake

This chapter is based on:

Hoefkens, C., Lachat, C., Kolsteren, P., Van Camp, J., & Verbeke, W. (2011). Posting point-of-purchase nutrition information in university canteens does not influence meal choice and nutrient intake. *American Journal of Clinical Nutrition*, *94*(2), 562-570.

Abstract

Growing concern over the relation between out-of-home eating and overweight has triggered the use of point-of-purchase (POP) nutrition information when eating out of the home. In canteens that offer various unhealthy choices, the posting of POP nutrition information has the potential to improve meal choices and dietary intakes. This chapter evaluates a nutrition-information intervention study with the objective to increase the proportion of consumed meals that comply with recommendations for energy, saturated fat, sodium, and vegetable content by 5%. A one-group pretest-posttest design was used. A total of 224 customers of two university canteens completed a questionnaire used for consumer profiling and three-day food records to assess their meal choices and nutrient intakes. The 12 best meal combinations received star ratings and descriptors for nutrients or food groups that did not comply. Findings indicate that the reported meal choices in canteens and nutrient intakes did not improve after the intervention ($p > 0.05$). The nutritional profile of the meal choice, obtained from a qualitative and quantitative nutritional assessment of meals, mirrored the nutritional profile of all meals offered ($p > 0.05$) and not that of the recommended meals offered ($p < 0.001$). Meal choices were not compensated for later in the day ($p > 0.05$). The healthiest choices were made by participants with greater objective nutrition knowledge, stronger health and weight-control motives, and a greater openness to change meal choices at baseline ($p < 0.05$). In conclusion, the posting of nutrition information in university canteens did not effectively

change meal choices and nutrient intakes. Despite the intervention, meal choices were largely determined by meals offered. Therefore, nutrition-information interventions in canteens may be more effective with a healthier meal supply.

6.1 Introduction

The increase in diet-related diseases worldwide is considered to be primarily caused by a changing environment (e.g. accessibility of out-of-home (OH) food outlets) that encourages poor dietary patterns and a sedentary lifestyle (Swinburn et al., 2004). The increased importance of OH eating in the habitual diet is potentially worrisome and has been associated with higher intakes of energy, fat, and sodium and insufficient amounts of fruit and vegetables (Ayala et al., 2008; Lachat et al., 2009; Orfanos et al., 2007; Vandevijvere et al., 2009). Most consumers are unaware of the inferior nutritional quality of foods consumed OH compared with at home. The provision of simple and easily accessible nutrition information on OH foods could benefit public health by facilitating healthier food choices (Burton et al., 2006).

Nutrition-information interventions have shown mixed results depending on the information provided (Chu et al., 2009; Harnack & French, 2008; Post et al., 2010; Seymour et al., 2004; Steenhuis et al., 2004; Wootan et al., 2006). Various studies have stressed the need for nutrition information that is comprehensive and easy to understand and use for consumers (i.e. so-called simplified nutrition information or signposting information) (Cowburn & Stockley, 2005; Grunert & Wills, 2007; van Kleef et al., 2008). Simplified nutrition labelling on prepacked foods that display the nutritional profile of a food has become an attractive instrument because of its behavioural rather than environmental approach to healthy eating by providing information while retaining consumer freedom of choice or the so-called “libertarian paternalistic” approach (Grunert & Wills, 2007; Thaler & Sunstein, 2008). A couple of recent studies have evaluated the effectiveness of such simplified nutrition labels on prepacked foods and showed promising results in terms of increased sales of targeted foods (Freedman & Connors, 2010; Sutherland et al., 2010). To our knowledge, it is not known whether and how such simplified nutrition information on OH meals (i.e. not prepacked) can influence the individual meal choice and intake of nutrients of canteen customers during lunch and on a daily basis.

When entering university, young adults become more independent and explore and develop their identity in a different social environment that often leads to different food choices and poorer dietary habits (Nelson et al., 2008). Many of these young adults rely regularly on the university canteen for their main meal (CMM UGent, 2009). The improvement of the dietary pattern of young adults is important because better nutritional habits at this stage of life will likely have positive effects on their future health (Winkleby & Cubbin, 2004).

The primary objective of this chapter was to evaluate the effect of posting point-of-purchase (POP) nutrition information in canteens on the meals chosen and consumed by customers (or meal choice) in terms of an increase in the proportion of meals that complied with all four meal recommendations (i.e. three-star meals). A secondary objective was to examine this intervention on the individual nutrient intake from the meal and the 24-h diet to check for compensatory behaviours during the remaining course of the day. Finally, the chapter aimed at profiling consumer subgroups according to the individual effectiveness of the intervention.

6.2 Methodology

6.2.1 Study area

The study was conducted between October 2008 and May 2009 in two canteens of Ghent University (Ghent, Belgium). The canteen of the Faculty of Bioscience Engineering (FBE) and the canteen of the Faculty of Psychology and Educational Sciences (FPES) were selected because of logistic advantages, their similarities in size and number of customers, and their equal meal supply. Both canteens served about 225 hot meals a day. Preparation methods and menus were standardized, and meals offered were largely the same in all canteens of the university. The menus composed by the canteen administration were not adapted for the purpose of this study. Besides a few fixed meals choices (e.g. spaghetti), customers could choose daily from four protein sources (e.g. meat), one or two warm sauces, two cooked vegetables, one salad, and five carbohydrate components (e.g. French fries) to compose their meal, which meant that about 180 meal combinations were possibly consumed each day. The meal consisting of these four components without any extra purchased food such as additional portions, dressings, fruit, other desserts, and drinks was defined as *canteen meal*. The same meal components were served throughout the year; only the fruit availability might have differed between seasons (e.g. mandarins only available during the fall). Because fruit were not included in the meal, the seasonal effect was expected to be negligible.

6.2.2 Study population

Participants were regular customers of one of the two mentioned university canteens, between the ages of 17 and 35 years, and essentially BSc, MSc, or PhD students. An open-recruitment procedure was applied, and potential participants were invited by email, flyers, and poster boards at both faculties or addressed in the classroom. A one-group pretest-posttest design was used in this study, which meant that each participant was exposed to the nutrition information and served as his or her own control as assessed at baseline (October and November 2008). The nutrition information was first posted one month before the follow-up measurement in April and May 2009. Participation was entirely voluntary and rewarded with one cinema ticket after completion of the baseline study and two additional tickets at the end of the follow-up study. The overall research procedure was explained to participants. To avoid demand effects, participants were not informed about the posting of nutrition information in the university canteens and were told the study measured eating habits in general. All participants provided written informed consent before entering the study. Together with the informed consent, participants completed a short questionnaire about their socio-demographic characteristics, body mass index (BMI), dieting, and smoking status. The study protocol was granted ethics approval by the Belgian Ethics Committee of the Ghent University Hospital (ethics approval number EC/2008/482) and is registered on ClinicalTrials.gov (Id number NCT01249508). Initial recruitment started on 15 October 2008.

6.2.3 POP nutrition-information intervention

Possible meal combinations were evaluated daily for the energy content, saturated fat, sodium, and vegetable portion. If a meal complied with a recommendation, it received a score of 1. The maximum score was 4. These scores were translated into stars, whereby the scores 2, 3 and 4 received, respectively, 1, 2, and 3 stars. We opted for a maximum of three stars to avoid the situation that a meal that complied with only one of the four recommendations would be considered as a healthier meal option worthy of one star. In addition, a three-star rating is a widely used quality appraisal in restaurants (e.g. Michelin stars). Besides the number of stars, non-complying nutrients or food group were posted in a red font and followed by an exclamation mark or "verbal descriptor" (example: Figure 6.1). The following meal recommendations were used for the evaluation of the meal: (1) meal supplied ≤500 kcal (otherwise posted as "Calorie!") (Belgian National Food and Health Plan, 2007), (2) the energy from saturated fat was ≤13% of the total energy supply (otherwise posted as "Saturated fat!") (Belgian Health Council, 2009; Independent Scientific Committee My Choice, 2008), (3) the amount of sodium in the meal was ≤2.2 mg Na/kcal (otherwise posted as "Salt!"), (4) the meal contained ≥150 g vegetables (otherwise posted as "Vegetable!")

(Belgian Health Council, 2009; Independent Scientific Committee My Choice, 2008). Of all possible meal combinations, the 12 best ones (i.e. the three best meal options for each of the four protein components) were selected. The binary score (0,1) for each nutrient and vegetable, as previously described, was translated into a secondary score ranging from 0 to 3. For example, a meal with an energy content of ≤500 kcal (i.e. energy recommendation) received a score of 3, a score of 2 corresponded with an energy content between 500 and 600 kcal, a score of 1 with an energy content between 600 and 700 kcal, and a score of 0 with an energy content ≥ 700 kcal. The sum of these secondary scores revealed a total score between 0 and 12 for each meal combination. All meal combinations were ranked based on this total score for each of the four protein components (meat, fish, or vegetarian) separately. The top 3 for each protein component was then selected and posted on large poster boards at the entrance of the canteens and next to example dishes at the buffet counter. During the three-week follow-up period, it occurred only once that the 12 best meal options offered did not include any three-star meals. Posters and brochures that explained the use of the nutrition information and the meal recommendations used to assign star ratings were available for consultation throughout the study canteens. Because consumers are less familiar with the terms *energy* and *sodium* than with the terms *calories* and *salt*, the latter terms were used in the nutrition information (Cowburn & Stockley, 2005; van Kleef et al., 2008). Each day before opening hours, the main researcher visited both canteens to post the nutrition information on the buffet counter and to check the availability of brochures. By having the nutrition information placed before opening hours and by formatting the supportive material according to the house style of all communications by the canteen administration, experimenter-demand effects were expected to be minimal. The canteen administration and staff were involved in the study from the outset to ascertain that no changes were made to their marketing and meals offered.

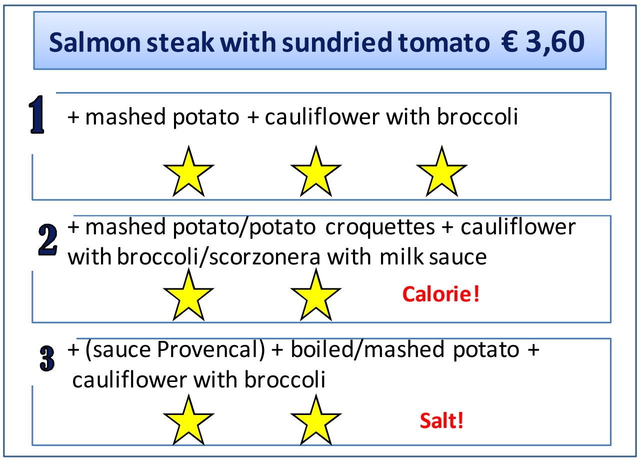


Figure 6.1 Example of the posted point-of-purchase nutrition information

6.2.4 Food intake data

Food intake data were obtained from a self-administered three-day food and drink record. The baseline study was conducted in a two-week period of regular activity in October and November 2008 (i.e. not just before or after a holiday and not during an examination period). Participants were asked to record all foods and drinks consumed during 24-h on three days chosen freely in that period according to their habitual schedule of eating at the canteen, which meant that the days recorded were not necessarily consecutive. The only condition was that participants had lunch in the canteen during these days. Because both canteens were closed on weekends, only weekdays were included in the food record. Instructions on how to complete the form were provided by researchers at the registration desk and on the form itself. The measurement of food intake was repeated with the same procedure at the 6-month follow-up (April and May 2009). The period of follow-up was three instead of two weeks because many participants reported to have fewer classes (thus, a lower presence at the university and a lower chance to eat in the canteen) in the second term (spring term) of the academic year compared with the first term (fall term). Portion sizes of canteen meals were obtained from the canteen administration, whereas other foods were quantified by using a standardized reference manual for foods in Belgium if exact quantities were not available (Belgian Health Council, 2005). For example, if participants reported to have consumed only six of eight potatoes of their canteen meal, the standard portion size of potatoes was reduced with two times the amount of a single potato to estimate the nutrient intake. The composition of meals was obtained from the technical files provided by the producers. For foods not served in the canteen (i.e. all foods eaten at home or during other occasions), nutritional composition data were taken from the Belgian food composition table (vzw Nubel, 2006). If data were not available from these sources, the Dutch food composition database (RIVM, 2010) and food labels were used to complete the food composition table. Collected data on food intakes were entered and processed with an online tool (Lucille, version 1; http://www.foodintake.ugent.be; Ghent University) developed to process 24-h dietary recall data. The average of the three recall days was used to assess the nutrient intake at lunch and on a daily basis.

6.2.5 Physical activity data

Together with their food intakes, participants were asked to record all physical activities for each 15-min period of a day. The time spent on each activity (in min) was multiplied with the corresponding metabolic equivalent coefficient (Ainsworth et al., 2000) and summed to obtain an individual estimation of energy expenditure for the three days of recording at both baseline and follow-up. An average was taken from the three days to obtain a measure of the amount of physical activity per day and period. The 15-min diary of physical activities has been validated against the doubly labelled water technique (Conway et al., 2002; Koebnick et al., 2005). Physical activity data were entered in MS Excel 2007 software (Microsoft Corp, WA, USA) and processed in Stata 11.0 software (Statacorp, College Station, TX, USA).

6.2.6 Individual characteristics for consumer profiling

The variables used for the profiling of consumer groups were assessed at baseline and estimated diet-health awareness, intention of dietary change, objective nutrition knowledge, meal-choice motives, and socio-demographic characteristics. The awareness of participants of the relation between diet and health was measured by using the 7-point Likert scale described by Ragaert et al. (2004) and consisted of three items (Cronbach's alpha = 0.64; e.g. "My health is determined by the food I eat"). The intention to change diet in the next six months was measured on a 7-point interval scale from "very unlikely" to "very likely" (5 items; Cronbach's alpha = 0.94; e.g. "In the next six months I plan to eat more healthy") (Ajzen, 2002). Objective nutrition knowledge was assessed by using the first part of the knowledge index (i.e. knowledge on dietary recommendations) developed by Grunert et al. (2010). Motives underlying the selection of canteen meals were measured by 19 items adapted from Steptoe et al. (1995). This scale assessed the degree to which participants placed importance on motives in making canteen meal choices by using a 7-point interval scale that ranged from ‘‘not at all important’’ to ‘‘very important’’ (e.g. "It is important to me that the meal I choose in a canteen is healthy"). An exploratory factor analysis that used the principal components extraction method with varimax rotation on these 19 items revealed five factors or motives as follows: health (3 items, Cronbach's alpha = 0.84), weight control (2 items, Cronbach's alpha = 0.90), sensory appeal (4 items, Cronbach's alpha = 0.64), price (3 items, Cronbach's alpha = 0.81), and familiarity (2 items, Cronbach's alpha = 0.87). The factors explained almost 65% of the variance in the original data. The internal reliability coefficient or Cronbach's alpha for all of these individual characteristics was satisfactory, and constructs were computed as the average of corresponding items. The complete list of scales and scale items used in the questionnaire are presented in Appendix II.

6.2.7 Statistical analyses

As many volunteers as possible were recruited, but only volunteers who provided complete dietary data at baseline and follow-up were retained for analysis. The aim was to show a 5% increase in the proportion of consumed meals that complied with all four meal recommendations. The 5% increase was chosen on the basis of a previous study in the same setting (Lachat et al., 2009) that showed that 5% of meal combinations chosen met all considered recommendations. A similar low percentage of compliance was expected at baseline. Doubling of the percentage was considered feasible and necessary for the intervention to be relevant for public health. In addition, doubling of the percentage was also considered as the minimum effect size by the canteen administration to upscale the information initiative to all university canteens. Power calculations were carried out with PASS v11 software (NCSS, UT, USA) for an inequality test for two dependent proportions from one sample.

Data analyses of the food intake data were carried out with Stata 11.0 software (Statacorp, College Station, TX, USA). Pearson's chi-square tests were conducted to assess significant differences in proportions between categories. Paired samples t-tests were performed to detect significant differences in mean nutrient intakes between baseline and follow-up. If there were non-normally distributed data and a lack of homogeneity of variance, a non-parametric Wilcoxon's signed-rank test was used. Differences in the nutritional profile between categories of meal choice or differences between consumer groups were calculated by using independent samples t-tests and one-way ANOVA's in case of normally distributed data, whereas Wilcoxon's rank-sum test was used for data that were not normally distributed. As an extension to the latter test, a simple test for the trend across ordered groups was performed to assess the presence of a trend in the nutritional profile across the meal star-rating categories. Results are expressed as means ± SDs, unless otherwise specified. P-values were considered statistically significant at $p < 0.05$. All statistical tests were two-sided.

6.3 Results

6.3.1 Description of participants

A total of 380 persons participated in the baseline study, and 59% of participants completed the follow-up study, which gave us 224 persons who completed both study periods. There were no differences between participants who dropped out and participants who completed the study in terms of socio-demographic characteristics, BMI, dieting, and smoking status (all $p > 0.05$, chi-square test; results not shown). General characteristics of the final sample are shown in Table 6.1. The final valid sample of 224 participants mostly consisted of regular canteen customers, undergraduates, and students who lived away from home during the week. This student sample mostly included women of about 21 years of age and in good health as indicated by their self-reported BMI, smoking status, and energy expenditure. There was no difference in the total reported energy expenditure before and after posting the POP nutrition information ($p = 0.275$). No differences were observed between the two canteens except for gender and age, and the latter difference was very small ($p < 0.05$). Data from both canteens were pooled because an evaluation of the effect of the intervention on the reported meal choice by canteen showed no difference in the proportion of chosen meals between star-rating categories for both canteens (FBW: p = 0.427, FPES: p = 0.607, chi-square test). Moreover, age (p = 0.074) and gender (p = 0.495) did not influence compliance of the meal choice with the recommended meals offered. The final sample size had a power of 91% to show an increase of 5% in the proportion of meals that complied with all four meal recommendations at a significance level of 0.05.

Table 6.1 Study sample characteristics in n (%)[1]

		Total sample	Canteen FBW	Canteen FPPW	p-value[2]
n (%)		224 (100.0)	94 (42.0)	130 (58.0)	
Customer frequency	< 1 times a week	30	12 (40.0)	18 (60.0)	0.603
	1 times a week	52	19 (36.5)	33 (63.5)	
	≥ 2 times a week	142	63 (44.4)	79 (55.6)	
Living away from home during week	Yes	146	59 (40.4)	87 (59.6)	0.519
	No	78	35 (44.9)	43 (55.1)	
Gender	Male	59	38 (64.4)	21 (35.6)	< 0.001
	Female	165	56 (33.9)	109 (66.1)	
Age (years)	Mean (SD)	21 (3)	22 (4)	21 (2)	0.002[3]
BMI status	Underweight	15	7 (46.7)	8 (53.3)	0.667
	Normal weight	188	78 (41.5)	110 (58.5)	
	Overweight	16	8 (50.0)	8 (50.0)	
	Obese	5	1 (20.0)	4 (80.0)	
BMI (kg/m²)	Mean (SD)	22 (3)	22 (3)	22 (3)	0.930[3]
Dieting	Yes	39	19 (48.7)	20 (51.3)	0.347
	No	185	75 (40.5)	110 (59.5)	
Smoking status	Yes	15	5 (33.3)	10 (66.7)	0.483
	No	209	89 (42.6)	120 (57.4)	
Energy expenditure (kcal)	Baseline: Mean (SD)	2558 (485)	2575 (469)	2552 (503)	0.486[3]
	Follow-up: Mean (SD)	2583 (508)	2580 (506)	2585 (511)	0.934[3]
	p-value[4]	0.275	0.959	0.159	

[1] Except if otherwise stated
[2] P-values from the chi-square test for comparison of sample characteristics between canteens 1 and 2
[3] P-values from the non-parametric Wilcoxon's rank-sum test (Mann-Whitney U-test)
[4] P-values from the non-parametric Wilcoxon's signed-rank test

6.3.2 Effect of posting POP nutrition information on canteen meal choices

The change in reported meal choice (i.e. meals selected and consumed) and meals offered (i.e. meals offered for sale) between baseline and follow-up is presented in Table 6.2. The proportion of meals chosen in the different star-rating categories remained relatively constant after posting the nutrition information ($p = 0.820$). An increase of only 1% was shown in the proportion of three-star meals compared with the expected increase of 5%. Meals offered included 2% more three-star meals ($p = 0.016$). About 70% of meal choices were meals without stars or with one star only, which was similar to the profile of the meals supplied. Posting nutrition information did not affect the number of meals chosen that complied with the meal recommendations for energy ($p = 0.660$) and vegetables ($p = 0.405$). Despite a decrease in the proportion of meals offered with too much saturated fat between baseline and follow-up, no significant change was observed in the reported meal choice for saturated fat ($p = 0.094$). After posting the nutrition information, an increase in the proportion of chosen meals with too much sodium was observed ($p = 0.005$). This finding was consistent with the meals offered, which also had more sodium-rich meal options after the introduction of the nutrition information ($p < 0.001$). In both periods, about two-thirds of meals chosen and offered contained too much energy and sodium, whereas about one-third supplied too much saturated fat and not enough vegetables.

From these findings, it appears that the meal choice simply mirrored the meals offered in terms of star ratings and non-complying nutrients or food group. There were no significant differences in the contents of energy, saturated fat, sodium, and vegetable portions between the meal choice and meals offered at baseline ($p > 0.05$) and between the meal choice and the meals offered at follow-up ($p > 0.05$) (data not shown).

Table 6.2 Change in reported meal choice and meals offered by star rating and label descriptor between baseline and follow-up

		Meal choice					Meals offered				
		Baseline (n = 657)		Follow-up (n = 664)			Baseline (n = 1460)		Follow-up (n = 2198)		
		n	%	n	%	p-value[1]	n	%	N	%	p-value[1]
Star rating	0 stars	245	37.3	243	36.6		410	28.1	599	27.3	
	1 star	230	35.0	235	35.4		646	44.3	947	43.1	
	2 stars	148	22.5	144	21.7		353	24.2	524	23.8	
	3 stars	34	5.2	42	6.3	0.820	51	3.5	128	5.8	0.016
Descriptor[2]	Calorie!	435	66.2	432	65.0	0.660	1007	69.0	1498	68.2	0.601
	SAFA!	279	42.5	252	38.0	0.094	470	32.2	552	25.1	<0.001
	Salt!	355	54.0	409	61.6	0.005	883	60.5	1521	69.2	<0.001
	Vegetable!	275	41.9	293	44.1	0.405	530	36.3	736	33.5	0.080

[1] P-values from the chi-square test for comparison of the number of meals in each star-rating category between baseline and follow-up

[2] Calorie!, SAFA!, Salt!, Vegetable!: meal not in compliance with the meal recommendation for energy (> 500 kcal), saturated fat (> 13 en%), sodium (> 2.2 mg/kcal) and vegetable (< 150 g), respectively

SAFA: saturated fatty acid

6.3.3 Effect of POP posting nutrition information on nutrient intake from canteen meals and daily diet

A similar meal choice before and after posting the nutrition information in terms of nutrients targeted by the intervention resulted in a non-significant difference in the nutrient intake from the canteen meal (Table 6.3). The intake of the targeted nutrients and the intake of non-targeted nutrients such as carbohydrates, protein, and total fat ($p > 0.05$) were not affected by the intervention. A significant increase in the consumed amount of vegetables from the meal was observed after posting the nutrition information ($p < 0.001$). This improvement was also significant when the total daily diet was considered ($p = 0.008$), although the vegetable consumption during other eating occasions than lunch in the canteen did not change (baseline: 65.3 (SD 59.4) g; follow-up: 62.7 (SD 62.1) g; $p = 0.324$). The results of the 24-h intake (except for carbohydrates ($p = 0.029$)) indicated that participants did not compensate for their canteen meal choice later during the day ($p > 0.05$).

Table 6.3 Change in consumer intake of targeted and non-targeted nutrients from the canteen meal and 24-hour diet between baseline and follow-up (n = 224)[1]

		Canteen meal			24-hour diet		
		Baseline Mean (SD)	Follow-up Mean (SD)	p-value[2]	Baseline Mean (SD)	Follow-up Mean (SD)	p-value[3]
Targeted nutrients /food group	Energy (kcal)	597 (114)	598 (98)	0.967	2113 (566)	2046 (533)	0.110
	Energy from SAFA (%)	11.52 (4.00)	11.81 (4.31)	0.381	12.29 (2.79)	11.97 (2.95)	0.201
	Sodium (mg)	1620 (499)	1652 (429)	0.392	3446 (901)	3379 (924)	0.263
	Vegetables (g)	167 (52)	189 (52)	<0.001	238 (87)	257 (90)	0.008
Non-targeted nutrients	Carbohydrate (g)	68 (15)	66 (15)	0.085	268 (75)	259 (71)	0.029
	Protein (g)	30 (6)	30 (6)	0.593	73 (16)	73 (26)	0.155
	Fat (g)	23 (8)	24 (7)	0.178	234 (150)	221 (158)	0.397

1 All values are means (SDs).
2 P-values from a paired samples t-test for comparison of the mean nutrient intake between baseline and follow-up
3 P-values from a non-parametric Wilcoxon's signed-rank test
SAFA: saturated fatty acid

6.3.4 Effectiveness of the POP nutrition information to categorize meals on the basis of their nutritional profiles

Compared with meal recommendations, a large proportion of meals chosen after posting the nutrition information still contained too much of targeted nutrients. Sixty-five percent and 62% of the meal choice did not comply with the meal recommendations for energy and sodium, respectively. Non-compliance with the advised saturated fat content and vegetable portion occurred in 38% and 44% of the meals chosen, respectively. The meals chosen provided an average of 598 (SD 159) kcal. The average saturated fat and sodium density of the meals were 11.82 (SD 7.18) % of energy from saturated fat and 2.77 (SD 1.06) mg Na/kcal. On average, a portion of 190 (SD 80) g of vegetables was included in the meals chosen by consumers.

To evaluate the effectiveness of the POP nutrition information, the nutritional profile of the reported meal choice was compared between star-rating categories as well as between categories by verbal descriptors (Table 6.4). A no-star meal supplied, on average, 667 (SD 151) kcal, 16.92 (SD 6.99) % of energy from saturated fat, 3.28 (SD 1.02) mg Na/kcal, and 173 (SD 79) g of vegetables, whereas a meal that earned three stars contained, on average, 423 (SD 56) kcal, 6.18 (SD 3.90) % of energy from saturated fat, 1.61 (SD 0.53) mg Na/kcal, and 208 (SD 21) g of vegetables. Consequently, the nutritional profile of meals with a higher star rating was significantly better (p for trend < 0.001).

Meal profiles that were based on energy, saturated fat, sodium, and vegetables corresponded to actual differences in the composition of meals for the respective descriptor. When participants consumed a recommended meal, consumers had a significantly lower intake of energy, saturated fat, and sodium and a higher vegetable intake ($p < 0.05$).

Meals that exceeded the recommendation for energy contained significantly higher amounts of sodium ($p < 0.001$) and vegetables ($p = 0.026$). The average energy content of meals too rich in sodium was significantly higher ($p < 0.001$). Meals with too much energy from saturated fat also supplied significantly higher contents of energy and sodium ($p < 0.001$). A significantly higher vegetable portion was observed for meals that had contents of sodium above the meal recommendation ($p = 0.004$). The meals consumed and profiled as supplying an insufficient portion of vegetables contained significantly more saturated fat ($p < 0.001$) and sodium ($p = 0.038$).

Table 6.4 Nutritional profile of the reported meal choice at follow-up by star rating and label descriptor[1] (n = 664)

	Star rating		Calorie!		SAFA!		Salt!		Vegetable!		Recommended[2]	
	Δ[3]	p for trend[4]	Δ[5]	p-value	Δ[5]	p-value	Δ[5]	p-value	Δ[5]	p-value	Δ[8]	p-value
Energy (kcal)	81	< 0.001	185	< 0.001[6]	97	< 0.001[6]	49	< 0.001[7]	-16	0.219[7]	-66	< 0.001[6]
Energy from SAFA (%)	4	< 0.001	1	0.055[7]	9	< 0.001[6]	0	0.113[6]	3	< 0.001[6]	-1	0.006[6]
Sodium (mg/kcal)	0.6	< 0.001	0.5	< 0.001[7]	0.5	< 0.001[6]	0.7	< 0.001[6]	0.3	0.038[6]	-0.3	< 0.001[7]
Vegetables (g)	-12	< 0.001	14	0.026[7]	19	0.269[6]	18	0.004[7]	-84	< 0.001[6]	17	0.002[6]

1 Calorie!, SAFA!, Salt!, and Vegetable! denote that the meal was not in compliance with meal recommendations for energy (>500 kcal), saturated fat (>13% of energy), sodium (>2.2 mg/kcal), and vegetables (<150 g), respectively.
2 The 3 best meal options per day for each protein component (meat, fish, or vegetarian) (n = 10 or 12) based on meal recommendations
3 Values are mean differences in nutritional profile between star-rating categories (from 0 to 3 stars)
4 P-values corresponding to the test for trend across ordered groups
5 Values are differences in nutritional profile between the category that did not comply with the meal recommendation and the category that was in compliance with the meal recommendation
6 P-values corresponding to the non-parametric Wilcoxon’s rank-sum test (Mann-Whitney U-test)
7 P-values corresponding to the independent samples t-test
8 Values are differences in the nutritional profile between recommended and non-recommended meals
SAFA: saturated fatty acid

Only 8% of participants chose a recommended meal on each of the three days they recorded their food intakes (Table 6.5). The majority of participants (n=164/224, 73%) either did not follow the daily meal recommendation at all (31%) or in only one of three times they made a meal choice (42%). Intakes of energy and sodium from the canteen meal showed a consistent downward trend with increasing compliance with the recommendations, whereas the vegetable intake was characterized by an increase ($p < 0.05$). Although not significant, the trend in the intake of energy from saturated fat lent further support to the observation that a higher compliance with the recommended meals offered was associated with an improved nutrient intake.

Table 6.5 Nutritional profile of the reported meal choice (Mean (SD))[1] at follow-up (n = 664) according to the compliance with the recommended meals offered[2]

Compliance of meal choice with recommended meals offered[2]	0 of 3 meal choices	1of 3 meal choices	2 of 3 meal choices	3 of 3 meal choices	p for trend[3]
n (%)	70 (31)	94 (42)	42 (19)	18 (8)	
Energy (kcal)	610 (92)	610 (93)	573 (115)	555 (88)	0.008
Energy from SAFA (%)	12.03 (4.31)	12.35 (4.34)	10.66 (4.16)	10.68 (3.96)	0.075
Sodium (mg/kcal)	2.93 (0.64)	2.72 (0.59)	2.68 (0.60)	2.66 (0.62)	0.009
Vegetables (g)	178 (56)	192 (52)	196 (48)	208 (28)	0.013

1 Except if otherwise stated

2 The 3 best meal options per day for each protein component (meat, fish, vegetarian) (n = 10 or 12) based on the following meal recommendations: ≤ 500 kcal energy, ≤ 13 % of energy from SAFA, ≤ 2.2 mg Na/kcal, ≥ 150 g vegetables

3 P-value corresponding to the test for trend across ordered groups

SAFA: saturated fatty acid

6.3.5 Consumer profiling

Participants who reported to have chosen recommended meals at least two of three times (27% of the sample) differed from the other subjects, with a significantly higher level of objective nutrition knowledge and a greater importance placed on health and weight-control motives in their canteen meal choices ($p < 0.05$) (Table 6.6). These participants were also more open to change and, thus, less restricted to familiar meal choices ($p = 0.001$). For the remaining variables (i.e. gender, age, BMI, energy expenditure, diet-health awareness, intention of dietary change, and sensory and price motives that underlie meal choices), no significant differences were shown between the three consumer groups ($p > 0.05$).

Table 6.6 Profiling of consumer groups (Mean (SD))[1] (n = 224) according to the compliance with the recommended meals offered[2] at follow-up

Compliance of meal choice with recommended meals offered[2]	0 of 3 meal choices	1of 3 meal choices	2 to 3 of 3 meal choices	p-value
n (%)	70 (31)	94 (42)	60 (27)	
Gender: female (n (%))	48 (29)	72 (44)	45 (27)	0.495 [3]
Age	20.5 (1.9)	21.5 (3.6)	22.1 (3.5)	0.074 [4]
BMI	21.6 (2.4)	21.5 (2.9)	22.4 (3.0)	0.114 [5]
Energy expenditure	2562 (484)	2502 (433)	2655 (562)	0.171 [5]
Diet-health awareness [6]	5.03 (0.90)	5.12 (0.89)	5.15 (0.73)	0.827 [5]
Intention of dietary change[6]	4.69 (1.00)	4.63 (1.24)	4.61 (1.28)	0.551 [5]
Objective nutrition knowledge[7]	8.44 (2.34)[a]	8.88 (3.11)[a]	10.03 (2.90)[b]	0.010 [5]
Health motive in meal choice[6]	5.38 (0.85)[a,b]	5.11 (1.09)[a]	5.53 (0.96)[b]	0.028 [5]
Weight-control motive in meal choice[6]	4.59 (1.35)[a,b]	4.12 (1.50)[a]	4.75 (1.32)[b]	0.016 [5]
Sensory motive in meal choice[6]	5.85 (0.73)	5.92 (0.69)	5.70 (0.73)	0.187 [5]
Price motive in meal choice[6]	5.68 (0.94)	5.70 (0.97)	5.48 (1.24)	0.410 [5]
Familiarity motive in meal choice[6]	3.75 (1.52)[b]	3.54 (1.29)[b]	2.84 (1.35)[a]	0.001 [5]

[1] Except if otherwise stated
[2] The 3 best meal options per day for each protein component (meat, fish, vegetarian) (n = 10 or 12) based on the following meal recommendations: ≤ 500 kcal energy, ≤ 13 % of energy from SAFA, ≤ 2.2 mg Na/kcal, ≥ 150 g vegetables
[3] P-value from the chi-square test
[4] P-value from the Kruskal-Wallis equality-of-populations rank test
[5] P-value from the one-way ANOVA
[6] Measured on a 7-point scale
[7] Measured as a score on 19
[a,b] Indicate significantly different means using one-way ANOVA

6.4 Discussion and conclusions

Canteen meals are important in the diets of many students and a wide range of adults in the workplace. However, when eating OH, customers might not be aware of the nutritional profile of their food choices and are consequently subjected to simply what is offered. Posting nutrition information on canteen menus has the potential to promote healthier choices when eating OH. However, our findings showed that nutrition information by using a star-rating system in combination with a descriptor of the non-complying nutrients or food group did not significantly affect meal choices during a canteen lunch or nutrient intakes at lunch or on a daily basis. Nevertheless, this star-rating system had the potential to positively influence the diet because it provided a good representation of the actual differences in meal compositions.

Only 27% of participants followed the daily meal recommendations at least two of three times.

Despite the intervention, the nutritional profile of the reported meal choice reflected nutritional characteristics of all meals offered and not of recommended meals offered, with the exception of vegetables. Only a few meals met all four meal recommendations (i.e. three-star meals). Although the vegetable consumption significantly increased after posting the nutrition information, this could not be attributed to the intervention. The number of meals consumed and offered with adequate vegetables did not significantly differ between baseline and follow-up. However, meals offered at follow-up contained slightly more vegetables (baseline: 181 (SD 48) g; follow-up: 187 (SD 29) g). Another possible explanation for the increase in vegetable intake was the increase in sodium-rich meals offered and, therefore, chosen, which happened to contain a significant higher amount of vegetables.

The nature of our sample (i.e. mostly women, who generally have greater weight-control involvement and a stronger interest in healthy eating than do men (Wardle et al., 2004) and with a higher educational level (Georgiou et al., 1997; Nelson et al., 2009) and the fixed moderate price of the canteen meals suggested that this nutrition-information intervention had the potential to alter meal choices and increase the proportion of three-star meal choices by 5%. However, the ineffectiveness of the intervention in this particular sample and setting showed the enormous challenge of changing dietary habits of young adults for whom price, taste, and appearance are often more important than the healthfulness of foods (Roininen et al., 1999; Verbeke, 2006). For future information initiatives in the catering sector, it is important to know that the intervention was most effective in participants who, at baseline, had a higher objective nutrition knowledge, stronger health and weight-control motives, and a higher openness to change meal choices.

This study aimed to evaluate a practical and simple method to improve healthy meal choices. Compared with more persuasive communications such as advertisements or sales techniques, a non-persuasive way to inform customers was used that did not actively try to influence them at the time of their meal choices. Posting POP nutrition information still requires an individual to make the healthy choice. Knowing that the meal choice reflects the meals offered, interventions in which the individual does not have to actively choose healthier foods because of a limited number of unhealthy choices may have a greater effect on healthy eating (Seymour et al., 2004) but is contradictory with the idea of libertarian paternalism.

Because the study rationale was to reflect the real-life setting and to not interfere in the planning of menus, different proportions of star ratings could occur between days. The number of 3-, 2-, 1-, and 0-star meals per day (at follow-up) among the best meal options of the day varied between 0% and 45%, 11% and 74%, 2% and 80%, 0% and 58%, respectively. To test for the effect of the different proportions of star ratings on the meal choice, the binary outcome variable (i.e. choosing a best meal option or not) was regressed on the percentage of 3-, 2-, 1-, and 0-star meals included in the 12 best meal options, respectively. The results indicated that the number of 3-star ($p = 0.006$) and 2-star ($p = 0.003$) meals were significant predictors for choosing a best or recommended meal, whereas the number of 1-star ($p = 0.935$) and 0-star ($p = 0.399$) meals were not statistically significant. For a 1% increase of 3- and 2-star meals in the meals offered, the odds of choosing a recommended meal (compared with not choosing a recommended meal) increased by 2% and decreased by 1%, respectively. These results illustrated the need for a healthy meal supply for nutrition information to be potentially effective in improving meal choices. Besides the real-life setting, the major strength of this study was the careful follow-up of the daily food consumption and physical activity of young adults in a free-living environment. Young adulthood is increasingly being recognized as an important period for health promotion and disease prevention because, for the majority of young people, it is the first time they have to make their own food choices (Nelson et al., 2008). The collection of individual 24-h consumption data as opposed to aggregated sales data allowed for the investigation of the possible occurrence of compensatory behaviours. Interestingly, participants did not positively or negatively compensate for their food choices at the canteen later during the day. Another strength of the study pertained to the use of science-based comprehensive and easy-to-use nutrition information for canteen meals that targeted disqualifying nutrients (e.g. saturated fat and sodium) and a qualifying food group (e.g. vegetable). In addition, to our knowledge, no nutrition-information intervention considered the individual taste preference next to healthfulness (Seymour et al., 2004). The highlighting of nutritional shortcomings of a meal may appear unacceptable to many caterers (Lachat et al., 2010) and may be less appealing for customers, which would form a barrier for its wider scale implementation.

Some limitations should be acknowledged when interpreting our findings. First, a one-group pretest-posttest design was used because randomization of canteens was impossible because of the insufficient number of canteens within Ghent University. Although susceptible to threats to validity associated with history, maturation, and testing, this quasi-experimental design without a control group was considered most appropriate because intact groups were required for this intervention (Campbell & Stanley, 1963). Because the time gap between the baseline and follow-up was relatively short, extraneous influences rather than the intervention, were assumed not to substantially change responses of participants. Such a possible threat was addressed by the comparison of energy expenditures between the baseline and follow-up, which confirmed that the amount of energy expenditure did not change (see Table 6.1). Second, to be inclusive, a convenience sampling approach was adopted, which is vulnerable to a sampling bias because of subject self-selection. However, this sampling would have favoured a positive effect of the intervention. Therefore, this intervention, when used on a population basis, would have equally produced no improvement in the actual meal choice and nutrient intake. Third, meal components were occasionally out of stock by the end of lunch time and replaced by food items that originally were not on the menu. This change in meals offered could not have been predicted and could, therefore, not have been covered by the intervention. To address this issue, the analysis was repeated without the meal choices that were not part of the menu. Similar results were obtained after the exclusion of these meals. Finally, the 1-month implementation period of the nutrition information in the canteens before follow-up measurement may have been too short to allow some participants to acquire the necessary interest and skills to use the information. However, the lack of an effect of the intervention was not expected to be due to missing supportive material because the availability of posters and brochures was checked daily by the main researcher.

In conclusion, posting POP nutrition information in canteens as implemented in this study was not effective in improving meal choices and nutrient intakes from the canteen meal and the total diet of students. Regardless of the nutrition-information intervention, the nutritional profile of the meal choice was largely determined by the meals offered. Compliers had a higher objective nutrition knowledge, stronger health and weight-control motives, and a higher openness to change meal choices. The current findings highlight that posting nutrition information in canteens requires a healthy meal supply to be effective in a larger population.

Chapter 7

Person-related factors influencing the effect of nutrition information in university canteens

This chapter is based on:

Hoefkens, C., Pieniak, Z., Van Camp, J., & Verbeke, W. Why posting point-of-purchase nutrition information in university canteens does not influence meal choice and nutrient intake. *Journal of the American Dietetic Association,* resubmitted.

Abstract

The importance of canteen meals in the diet of many university students makes the provision of simple point-of-purchase (POP) nutrition information in university canteens a potentially effective way to promote healthier diets in an important group of young adults. However, modifications to environments such as the posting of POP nutrition information in canteens may not cause an immediate change in meal choices and nutrient intakes. This chapter aimed at understanding the process by which the POP nutrition information achieved its effects on the meal choice and energy intake and whether the information was more effective in changing the meal choice of subgroups of university students. Data of theoretical mediating variables and the energy intake from canteen meals collected at baseline (2008) and follow-up (2009) of the nutrition-information intervention were used in a structural equation model to test causal pathways of information effects. A sample of 224 customers of two university canteens were included in the study. Significant relations were identified between liking of the information and its use on one hand and a change in attitude towards healthy canteen meals on the other hand. Motivation to change diet and sufficient objective nutrition knowledge were required to maintain a recommended energy intake from canteen meals or to lead to a decrease in energy intake. Students with greater objective nutrition knowledge had a greater understanding of the POP nutrition information which resulted in an effective use of the information. Our findings suggest that nutrition-information interventions will be more effective when using nutrition information that is generally liked by the target population in combination with an educational intervention to increase objective nutrition knowledge.

7.1 Introduction

Young adults often establish unfavourable dietary habits when leaving the parental home to enter university, i.e. consuming a diet of limited variety, high snacking, consuming more high-fat foods (including fast foods), more soft drinks, and less fruit and vegetables (Brunt & Rhee, 2008; Levitsky et al., 2004; Nelson et al., 2008). Such habits may have a long-lasting impact on their own health or the health of their future families (Nelson et al., 2008; Winkleby & Cubbin, 2004). Therefore, it is important to promote maintenance of adequate nutritional habits learned at home or to improve current eating habits.

For many university students canteen meals constitute an important part of the diet (CMM UGent, 2009). Because canteen customers might not be aware of the nutritional quality of their meal choices (Burton et al., 2006), which are often too rich in energy, fat and sodium, and contain insufficient amounts of fruit and vegetables (Kjollesdal et al., 2011; Lachat et al., 2009), dietary guidance through simplified point-of-purchase (POP) nutrition information on menu choices in canteens could be a strategically important approach to promote healthy dietary choices.

Evaluation of the overall effect of a POP nutrition-information intervention in two canteens of Ghent University showed that nutrition information by using a star-rating system as signage did not effectively change meal choices and nutrient intakes (Hoefkens et al., 2011a). Modifications to the environment such as posting nutrition information in university canteens might not cause an immediate dietary change (Holdsworth & Haslam, 1998). Consumer behaviour and information processing models posit that only information that is effectively processed by an individual may affect his or her beliefs, attitudes and behaviour (Verbeke, 2008). In addition, the effect of nutrition information on dietary behaviour may differ between individuals (Drichoutis et al., 2006; Moorman & Matulich, 1993). To examine causal pathways of information effects on determinants of canteen meal choices for consumer subgroups, moderated mediation models are especially valuable. In these statistical models, a third variable mediates the effect of an independent variable on the dependent variable, and this mediated or indirect effect depends on the level of a moderator (i.e. conditional indirect effect) (MacKinnon et al., 2007). Despite the acknowledged importance of investigating mediation and moderation effects of interventions on dietary behaviour, only few studies have done so and none of them have evaluated a nutrition–information intervention in a canteen environment (Kristal et al., 2000; Lockwood et al., 2010).

The objective of the study was to explain the ineffectiveness of our nutrition-information intervention in university canteens (Hoefkens et al., 2011a). A moderated mediation model was estimated to examine, first, the process by which the POP nutrition information achieved its effects on the meal choice and energy intake, and second, whether the information was more effective in changing the meal choice of subgroups of university students. From consumer behaviour models, our first hypothesis was that individuals who understand and like the POP nutrition information, will be more likely to use the information, will increase their subjective knowledge about how to evaluate the healthiness of a food, leading to a more positive attitude towards healthy canteen meals and ultimately to a healthier meal choice (Figure 7.1). A second hypothesis was that the POP nutrition information would be most effective among more motivated and more knowledgeable individuals (Moorman & Matulich, 1993). Because the information was designed to facilitate the identification of healthier meal choices, also less knowledgeable consumers with a high motivation to change their diet were hypothesized to be positively influenced by the intervention.

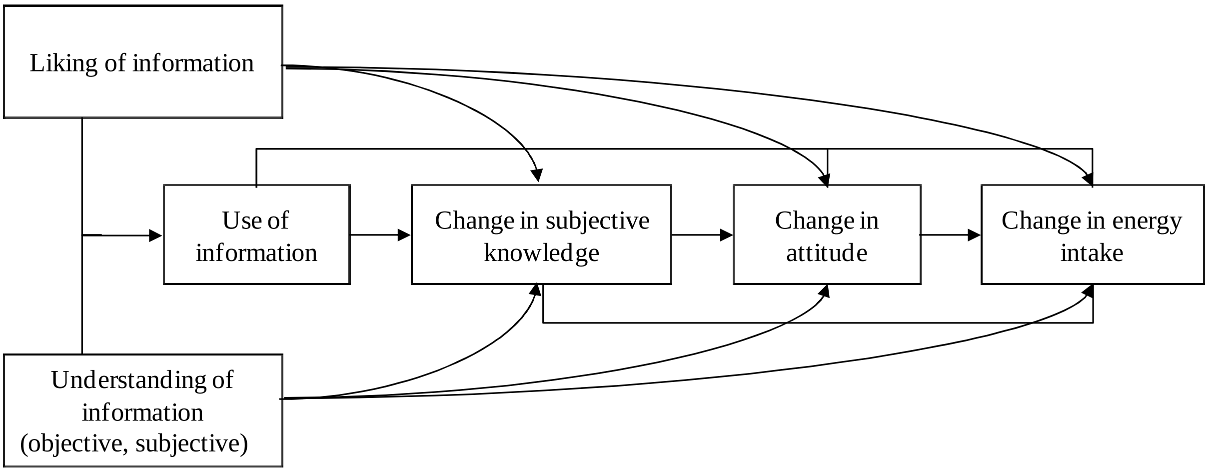


Figure 7.1 Hypothetical model of the process by which the nutrition information achieves its effects on the meal choice and energy intake

7.2 Methodology

7.2.1 Study design and population

The nutrition-information intervention that forms the starting point of the present study used a one-group pretest-posttest design. A convenience sample of 224 students (165 females and 59 males) between the ages of 17 and 35 years (Mean 21 years, SD 3), who were regular customers of two canteens of Ghent university (Belgium), enrolled in the intervention and completed three-day food records and self-administered structured questionnaires at baseline (October and November 2008) and follow-up (April and May 2009). The nutrition information, posted in March 2009, was implemented on the 12 best meal combinations and consisted of a star rating ranging from zero to three stars and a descriptor for nutrients or food group that did not comply with recommendations for energy (>500 kcal), saturated fat (>13% of energy), sodium (>2.2 mg/kcal), and vegetable (<150 g) (Belgian Health Council, 2009; Belgian National Food and Health Plan, 2007; Independent Scientific Committee My Choice, 2008). Participants were not informed about the posting of nutrition information but only about the study purpose of measuring eating habits. A more detailed description of the nutrition–information intervention, the sample characteristics and results in terms of meal choice and nutrient intake are provided in Chapter 6. The study protocol was granted ethics approval by the Belgian Ethics Committee of the Ghent University Hospital (ethics approval number EC/2008/482) and registered on ClinicalTrials.gov (Id number NCT01249508) .

7.2.2 Measures

*Behavioural outcome***.** The primary outcome variable of the intervention was the number of chosen meals that complied with all recommendations (i.e. three-star meals) (Hoefkens et al., 2011a). Because the moderated mediation model requires a continuous outcome variable, the present study used the energy intake from the canteen meal as a proxy for the star-rating of the reported meal choice. The energy intake from the canteen meal at both baseline and follow-up were calculated as the average of the three days collected through self-administered three-day food records together with the energy values and standardized portion sizes of the meal components provided by the caterer. Based on the difference in energy intake from the canteen meal between follow-up and baseline, participants were categorized into (1) increasing energy intake (i.e. increase of more than one standard deviation with SD = 147 kcal), (2) maintaining high energy intake, (3) maintaining moderate energy intake, (4) maintaining low or recommended energy intake and (5) decreasing energy intake (i.e. decrease > 147 kcal). The mean, SD and range of the outcome variable are presented in Table 7.1.

Theory-based mediators. The theoretical framework of the nutrition-information intervention was based on a combination of the model of consumer information processing proposed by Grunert and Wills (2007) and the Hierarchy-of-effects (HOE) model (Lavidge & Steiner, 1961).

The hypothesized mediators related to information processing were liking of the information (3 items; Cronbach’s alpha = 0.81) (Almanza & Hsieh, 1995; Feunekes et al., 2008), subjective understanding (3 items; Cronbach’s alpha = 0.80) (Obayashi et al., 2003), objective understanding (aggregated score on 14 items; see further) and self-reported use of the information (5 items; Cronbach’s alpha = 0.93) (Fitzgerald et al., 2008). A description of the items and construct variables are provided in Table 7.1. Liking was measured on a 7-point interval scale from "totally not like the information" to "like the information very much", while the subjective understanding of the information was rated on a 7-point Likert scale. For objective understanding, an index was computed counting the number of correct answers to 14 multiple-choice questions on the definition and the interpretation of the star-rating information (scores from 0 to 14). To assess usage of the information, participants were asked to rate on a 7-point scale how often (ranging from never to always) they used the information for their meal choices.

Two potential mediators derived from the HOE model were "change in subjective knowledge" about the healthiness of a food and "change in attitude" towards healthy canteen meals. Subjective knowledge (4 items; Cronbach's alpha: baseline = 0.75, follow-up = 0.81) (Pieniak et al., 2010) and attitude (single item) (Acharya et al., 2006) were measured at baseline and follow-up by asking participants' agreement with a series of questions on a 7-point Likert scale. For the change in subjective knowledge a score of one to five was assigned as follows: (1) negative change in knowledge, (2) maintaining low knowledge, (3) maintaining moderate knowledge, (4) maintaining high knowledge, (5) positive change in knowledge. The same classification procedure was used to derive change in attitude with five final categories: (1) negative change in attitude, (2) maintaining low attitude, (3) maintaining moderate attitude, (4) maintaining high attitude, (5) positive change in attitude. A decrease and increase in knowledge or attitude from baseline to follow-up of more than one standard deviation (with SD = 1.34 for change in attitude; SD = 0.94 for change in subjective knowledge) on a 7-point scale was used to classify participants under categories 1 and 5, respectively.

Theory-based moderators. The potential moderators of the intervention effects were defined on the basis of the objective nutrition knowledge and intention to change diet at baseline. Four subgroups of individuals were compared: those with (1) high knowledge and high intention (n = 44), (2) high knowledge and low intention (n = 54), (3) low knowledge and high intention (n = 70), (4) low knowledge and low intention (n = 52). Objective nutrition knowledge was determined using the index of knowledge on dietary recommendations developed by Grunert et al. (2010). High versus low knowledge was defined as a score of more versus less than 8.5 on 19 items. Participants' intention to change their diet in the next six months (used as a proxy for motivation to change diet) was measured on a 7-point interval scale from "very unlikely" to "very likely" (5 items; Cronbach's alpha = 0.94) (Ajzen, 2002). A median split (cut-off = 4.7) was used to form high and low subgroups on intention of dietary change.

The complete list of scales and scale items used are presented in Appendix II.

7.2.3 Statistical analyses

Data were analyzed using the robust maximum likelihood procedure in LISREL 8.72 (Jöreskog & Sörbom, 1989). To provide insights in differences between the four subgroups (characterized by moderating factors), a multi-group structural equation modelling (SEM) analysis was conducted. By using SEM, the examination of all the relations between constructs and items was performed simultaneously, which is a substantial advantage compared with single equation modelling (Bollen, 1989). This model also enables to examine relations between variables, such as mediators and moderators, in a simultaneous way (by means of multi-group analysis) that many other techniques cannot (Hair et al., 2006).

Correlation coefficients were first calculated between the variables of interest. All correlations were below 0.70, thus multicollinearity was not a concern in the present data (Tabachnick & Fidell, 2001). SEM parameters were then estimated and the general fit of the model was assessed first for the total sample and then for the four subgroups based on nutrition knowledge and intention of dietary change. To evaluate the fit of the model, the χ^2-value together with degrees of freedom are reported, as well as four other indices: the root mean square error of approximation (RMSEA), the normed fit index (NFI), the non-normed fit index (NNFI) and the comparative fit index (CFI). Values below 0.08 for RMSEA (Browne et al., 1993) and above 0.90 for NFI, NNFI and CFI (Bollen, 1989) indicate an acceptable fit between the model and the data.

Table 7.1 Description of items and construct variables (mean, SD, range) for the total sample, subgroup with low knowledge and high intention, and subgroup with high knowledge and high intention

	Total sample (n=220)[1]		For subgroup with low knowledge and high intention (n=70)		For subgroup with high knowledge and high intention (n=44)	
	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range
1. Change in energy intake	1.10 ± 147	914	-27.88 ± 132	765	-30.66 ± 126	485
2. Change in attitudes[2]	-0.69 ± 1.34	10	-0.61 ± 1.15	5	-0.64 ± 1.35	6
3. Change in subjective knowledge[3]	-0.05 ± 0.94	7.25	-0.12 ± 0.99	6.75	-0.07 ± 0.71	3
4. Use of information[4]	2.90 ± 1.51	6	3.03 ± 1.47	5.6	3.21 ± 1.52	5
5. Subjective understanding of information[5]	4.54 ± 1.25	6	4.54 ± 1.23	5.67	4.45 ± 1.17	5
6. Objective understanding of information	10.19 ± 2.25	13	9.63 ± 2.29	11	10.32 ± 1.91	11
7. Liking of information[6]	4.35 ± 1.06	5.33	4.43 ± 1.02	5	4.56 ± 1.00	4.33

[1] Four individuals were removed from the sample because of incomplete information, leaving a final sample of 220 valid cases.

[2] Item to measure attitudes (7-point Likert scale): "Canteen meals that are designated as healthy choices are better for me".

[3] Items to measure subjective knowledge (7-point Likert scale): "My friends consider me as an expert in healthy foods"; "I have a lot of knowledge about how to prepare a healthy meal"; "I know which food is healthy for me"; "I have a lot of knowledge about how to evaluate the nutritional value of a food".

[4] Items to measure use of information (7-point interval scale): I use the information "to make my meal choice"; "to choose the healthiest meal"; "to avoid meals containing too much energy"; " to avoid meals containing too much saturated fat"; "to avoid meals containing too much sodium (salt)".

[5] Items to measure subjective understanding (7-point Likert scale): The information is "hard to interpret"; "hard to extract"; "difficult to understand".

[6] Items to measure liking of information (7-point interval scale): "I like the information"; "The information is attractive to me"; "The information is interesting to me".

7.3 Results and discussion

Goodness-of-fit of the models. The hypothesized model as presented in Figure 7.1 performed well for the total sample (Table 7.2). The χ^2 for the model was 172.58 with 74 degrees of freedom ($p < 0.001$). The RMSEA value was 0.078; the CFI was 0.96, the NNFI was 0.94 and the NFI was 0.93, indicating that the goodness-of-fit indices were satisfactory (Bollen, 1989; Browne et al., 1993). Also the data by subgroup fitted the model well (but not as good as for the total sample). The χ^2 for the model was 439.35 with 320 degrees of freedom ($p < 0.001$). The RMSEA value was 0.083; the CFI was 0.95, the NNFI was 0.93 and the NFI was 0.83.

Role of liking. Overall, one significant relation was confirmed in each of the four investigated subgroups, namely the relation between liking and use of the information. This association was also found to be the strongest, indicating that people who liked the information more, declared to use the information more often. A moderate significant path from liking of the information to change in attitudes or high attitudes was observed, both directly and indirectly through claimed usage of the information. The direct path from liking to change in attitude was also found in the subgroup with low knowledge and high intention.
Compared to the understanding of the information, liking was a more important predictor of information use. This finding highlights the need for communication efforts and research to move beyond a focus on "understanding of nutrition information" and to emphasize more the liking and attractiveness of information formats. It seems that most consumers have a reasonable understanding of nutrition information when prompted, but only a minority seems to look for nutrition information when shopping (Grunert et al., 2010). The present study confirmed the general good level of objective understanding of POP nutrition information with less than 10% of the sample having a score of below 7 on 14. Liking of the information was more heterogeneous among the sample with 25% having a score of less than 4 on a 7-point scale. These findings suggest that information characteristics (e.g. display size, colour scheme), which are key determinants of consumers' attention to nutrition information (Bialkova & van Trijp, 2010) and liking of the information (Berning et al., 2010), may offer a window of opportunity to improve the effectiveness of nutrition information in terms of targeted dietary change.

Nutrition knowledge versus motivation. Participants needed both to like and (objectively) understand the information to use it, leading to a decrease in energy intake or maintenance of the recommended energy intake level, as shown in the subgroup of high motivated and knowledgeable consumers. Objective knowledge has also previously been reported to act as a moderator of the relation between objective understanding and use of the information on one hand (Grunert et al., 2010), and between use and change in energy intake on the other hand

(Drichoutis et al., 2006). Compared to this subgroup, the total sample reported a significantly lower objective nutrition knowledge (P<0.001). Although simplified nutrition information does not require detailed nutrition knowledge (Feunekes et al., 2008); some level of knowledge seems necessary to result in effective usage of the information (Verbeke, 2008). Moreover, higher nutrition knowledge may also indicate a higher interest in nutrition and healthy eating (Worsley, 2002). These findings suggest the need for more nutrition education.

A more important moderator of participants' responses to nutrition information was their motivation to change diet as illustrated by the outcome of the multi-group analysis, which was also consistent with previous studies (Keller et al., 1997; Moorman, 1990). In addition to nutrition education, the challenge is to investigate how to motivate people (more) to change dietary habits.

Objective versus subjective understanding of the posted information. The distinction between objective and subjective understanding was first made by Grunert & Wills (2007), but no study thus far analyzed the importance of subjective understanding in explaining consumers' use of nutrition information. In this study, no significant association was found between subjective understanding and the use of the information, except for the subgroup with high knowledge and high motivation, for whom the relation was negative. A possible explanation was that the more knowledgeable participants were, the more they tended to underestimate their own performance compared with that of peers (Battistelli et al., 2009). In the total sample and in the subgroup of participants with low knowledge and high intention, a significant association between objective and subjective understanding was observed.
Moreover, for the total sample, subjective understanding was negatively associated with a change in energy intake, but positively with a change in subjective knowledge. This could indicate that an important segment of our sample was in a learning stage – hence, not (yet) ready for action – which is comparable to the motivational phase as defined by Renner and Schwarzer (2003) and the contemplation or preparation stage of change described by Prochaska & Velicer (1997). Simultaneously, the same relations between subjective understanding and change in energy intake on one hand and subjective knowledge on the other hand were observed in the subgroups with low intention, which indicated that part of this learning segment may probably never evolve to behavioural change because of a lack of personal motivation. Again the importance of personal motivation is highlighted.

Intervention effect on subjective knowledge. An increase in subjective knowledge or maintenance of high subjective knowledge was found to result from a higher use of the information, but not because of a higher objective understanding of the information. Subjective knowledge is usually defined as people's subjective perceptions of what or how much they know about a specific product compared with peers (Park et al., 1994; Selnes & Gronhaug, 1986). In the present study, we did not measure the perceived knowledge of products but of skills (i.e. to evaluate the nutritional value and healthfulness of a food), which is often referred to as self-efficacy (Bandura, 1986). Previous studies have indicated that although nutrition information may not have an immediate effect on food choices and dietary intake, such information may act together with other factors to enhance consumers' self-efficacy and thereby increase the likelihood of healthier food choices being made later on (Contento et al., 2002; Holdsworth & Haslam, 1998). Therefore, a nutrition-information intervention that targets self-efficacy may, in the long run, lead to dietary changes.

Relation between attitude and behaviour. The results for the subgroup of high motivated and knowledgeable consumers support a positive relation between attitude towards healthy eating and dietary behaviour (Hearty et al., 2007; Petrovici & Ritson, 2006). Again this suggests that some baseline level of nutrition knowledge may be necessary to translate a positive attitude into a lower energy intake. In general, the attitude towards healthy canteen meals decreased after posting the information (paired sample's t-test $p < 0.001$), which can be explained by the limited number of healthy meal choices. Improving this attitude by increasing the offer of healthy choices might therefore be an important step forward in the development of effective strategies for stimulating healthier meal choices.

Strengths and limitations of the study. The major strength was the application of a new advanced approach to the evaluation of intervention effects in nutrition research. Another strength of the study was the careful follow-up of the daily food consumption of young adults and its determinants in a real-life setting. Some limitations should also be acknowledged. First, the use of a convenience sample limits the interpretation of the findings to its specific sampling frame. Extrapolation to other populations remains to be further validated. Second, the small sample size may have limited the ability to detect significant differences in more personal factors with sufficient power. Third, the limited duration of follow-up did not permit evaluations of gradual behavioural changes and persistence of behavioural change over time.

Table 7.2 Standardized solutions for hypothesized relationships between intervention, mediators and behavioural outcome for different groups[1]

Construct	Path	Construct	Low knowledge high intention (n = 70)	High knowledge high intention (n = 44)	Total sample (n = 220)[2]
Change in attitude	→	Change in energy intake		0.41	
Use of information	→	Change in energy intake		0.46	
Subjective understanding of information	→	Change in energy intake			-0.18
Liking of information	→	Change in energy intake			
Use of information	→	Change in attitude			0.19
Liking of information	→	Change in attitude	0.31		0.29
Use of information	→	Change in subjective knowledge			0.24
Subjective understanding of information	→	Change in subjective knowledge			0.17
Subjective understanding of information	→	Use of information		-0.27	
Objective understanding o information	→	Use of information		0.38	
Liking of information	→	Use of information	0.58	0.90	0.59
Objective understanding of information	→	Subjective understanding of information	0.28		0.20

1 Only paths with at least one significant coefficient in any of the three models are included

2 Four individuals were removed from the sample because of incomplete information, leaving a final sample of 220 valid cases

7.4 Conclusions

The proposed moderated mediation model of nutrition-information effects contributed to a better understanding of the ineffectiveness of a nutrition-information intervention in university canteens. The model highlighted the importance of liking of the posted information. The nutrition information was more effective for the more motivated students and for those with a greater objective nutrition knowledge. Increasing students' motivation to change their diet and, to a lesser extent, their knowledge is recommended. Additionally, creating an eating environment with more healthy choices and attractive POP nutrition information complemented with the provision of nutrition education, is proposed for the development and implementation of effective nutrition-information strategies.

Chapter 8

Consumer preferences for alternative formats of nutrition information in university canteens

This chapter is based on:

Hoefkens, C., Veettil, P. C., Van Huylenbroeck, G., Van Camp, J., & Verbeke, W. What nutrition label to use in a catering environment? A discrete choice experiment. *Food Policy,* submitted.

Abstract

Worksite and university canteens are increasingly used for main meal consumption. Following the use of simplified nutrition information on food labels of prepacked foods, the provision of easily accessible nutrition information on foods prepared and consumed out of home is a highly topical policy issue with potential to help consumers make better informed and more healthy food choices when eating out. Information presented in a format that is preferred by the target group is more likely to be used. A sample of 1725 university students participated in a web-based choice experiment designed to identify and understand individual preferences for alternative nutrition labels on canteen meals. The findings suggest that participants valued the presence of nutrition information on canteen meals and showed a preference for more detailed nutrition label formats. Ability and motivation to process information as well as socio-demographics explained differences in label format preferences. Observed decreasing marginal utility from combinations of two simplified label formats as well as from combinations of two detailed formats, signal information insufficiency versus information overload. In order to satisfy most students' information needs, a nutrition label containing basic guideline daily amounts as numerical information in combination with familiar interpretational visual aids like stars and colour codes is proposed for use in university canteens.

8.1 Introduction

Consumers' increased demand for information about the health characteristics of foods has motivated food manufacturers and retailers to provide nutrition information on their food labels (Verbeke, 2005). Recently, different front-of-pack (FOP) simplified nutrition labels have been introduced voluntarily as a complementary scheme to the EU regulated back-of-pack nutrition table (EC Regulation 90/496), and nutrition and health claims on prepacked foods (EC Regulation 1924/2006). Examples are the guideline daily amounts (GDA) and traffic light label (TL). These simplified nutrition labels differ from the traditional nutrition tables in the amount and presentation of the nutrition information and therefore, would require less time and effort to be processed. From a public health and food policy point of view, providing consumers with summarised nutrition information at the point of purchase may help them to easily identify and (hopefully) choose the healthier foods. Marketers, for their part, have an interest in nutrition labelling to develop strategies to better differentiate their food products in the market and to build and maintain nutrition- and health-related competitive advantages. Both from a public and private perspective, it is important to identify and understand consumers' preferences for alternative nutrition information formats (Grunert & Wills, 2007).

Due to rising overweight and obesity rates (WHO, 2011a) and the increased reliance on food away from home (FAFH) (Guthrie et al., 2002; Orfanos et al., 2007), there is ongoing debate on whether to adopt mandatory nutrition labelling in the FAFH sector. FAFH have been blamed for hindering the potential beneficial effects associated with label use due to the increased substitution of at-home consumption of prepacked foods, which the EU regulation supports, with away-from-home consumption (Drichoutis et al., 2006). Frequent out-of-home (OH) consumption has been associated with higher energy intakes, and a higher prevalence of overweight and obesity (Ayala et al., 2008; Orfanos et al., 2007; Vandevijvere et al., 2009). Additionally, most consumers seem to underestimate the nutrient content of FAFH (Burton et al., 2006). Given the possible mismatch between the perceived and actual nutritional value of FAFH, the inclusion of nutrition information on the menu could benefit consumers by effectively transforming the nutrient content, a typical credence attribute, into a search attribute (Caswell & Mojduszka, 1996), and herewith reduce uncertainty and information asymmetry for FAFH choices. Moreover, consumers demand high-quality foods, apparently with as much information as possible, but at the same time they often experience time constraints and a lack of motivation and skills to process information (Verbeke, 2005). This suggests that simplified nutrition labelling is a potentially interesting policy tool also for FAFH. Other cues or indicators of quality frequently used in situations of time pressure are the price and brand name of the food product (Gracia et al., 2009). In the context of OH eating, brand names might not be important, but the price is (Hwang & Lorenzen, 2008) and will, therefore, be included in the choice experiment to allow a monetary valuation of the food information attributes.

Previous consumer research on nutrition labelling has mainly focused on the use and understanding of on-pack nutrition information and its effect on consumer decision-making (reviewed by Campos et al. (2011), Cowburn and Stockley (2005), Drichoutis et al. (2006), Grunert and Wills (2007). It was concluded that most consumers are able to find and use simple numerical information for making simple comparisons between products for consumption at home, but their ability to interpret nutrition labels decreases as the complexity of the tasks increases. Therefore, it was suggested to add interpretational aids like verbal descriptors (high, medium, low) and recommended reference values to assist consumers in making more informed food choices. Since the introduction of the traditional back-of-pack nutrition tables, several stakeholders (food manufacturers and retailers, governmental and non-governmental organisations) have been focussing on these interpretational aids resulting in a wide range of additional FOP nutrition information labels. Different classifications of simplified nutrition labels have been suggested in literature (Feunekes et al., 2008; Grunert & Wills, 2007; Storcksdieck genannt Bonsmann et al., 2010a) based on their level of simplicity (simple versus complex), comprehensiveness (basic versus detailed) and/or coerciveness (non-directive, semi-directive, directive). An overview of FOP labels can be found in European Heart Network (2007). To date the question remains in which format simplified information on pack should preferably be made available to consumers (Möser et al., 2010).

The presence of multiple nutrition labels on food packages is likely to further confuse consumers (van Trijp, 2009). Nutrition labels have been found to be positively valued by consumers when presented individually, but often negatively when appearing together (Barreiro-Hurle et al., 2009, 2010). Consumers are clearly facing increasing nutrition information on pack which may eventually yield information overload. Although consumers say they want more information, being faced with too much information and limited time and motivation to process information may simply cause them to opt out of the nutrition information search process in order to protect themselves from information overload and resulting uncertainty (Caswell & Padberg, 1992).

A few studies have been examining differences in consumer preferences for FOP labelling. Feunekes et al. (2008) found that simple symbols were more appropriate in a shopping environment compared to the more detailed labels due to the lower processing time needed, while differences in perceived consumer friendliness and usage intention between both formats were minor. Best performing FOP labelling formats according to the study by UK

Food Standards Agency are Multiple TL (MTL) and Colour-coded GDA (CGDA) compared to Simple TL and Monochrome GDA (Food Standards Agency, 2005). MTL performed best in the individual product evaluation, while CGDA performed better when comparing two products. A recent study by the British Market Research Bureau for FSA concluded that the strongest FOP labels are those which combine text (high, medium, low), TL colours and % GDA information (Malam et al., 2009). Regarding labelling characteristics (such as display size, position of the label on FOP, colour scheme), research by Bialkova and van Trijp (2010) found that the presence rather than absence of a nutrition label printed on a consistent location on the package, with a doubled display size and with mono- rather than polychromatic colouring were key success factors for attracting consumer attention. A choice experiment assessing consumers preferences regarding nutrition labels revealed that the easy-to-use format may benefit more shoppers than the detailed format (Berning et al., 2007). These findings are important for the outlook of nutrition labels in the FAFH sector. To date no other study has been covering the FAFH market with the exception of the study by Drichoutis et al. (2009), which concluded that consumers are willing to pay more for FAFH with nutrition information and that they value the EU nutrition table and TL label more than the US nutrition facts panel.

The current chapter extends the literature on nutrition information preferences by an evaluation of simplified nutrition labels in a specific OH context, namely university canteens. Presenting canteen customers with nutrition information in a preferable format may increase its use and eventual health impact. Observed heterogeneity in the preference of nutrition information in grocery stores is also expected to exist in a canteen environment which highlights the importance for canteens to identify label format preferences of their customers. Specifically, the present chapter addresses two research questions: (1) To what extent do consumers prefer simple nutrition labels to more detailed labels on meals served in a catering environment? and (2) To what extent do specific determinants of label use and liking influence the nutrition label preferences?

These research questions were analysed using a stated choice modelling approach since consumers' preferences for various nutrition labelling formats were assumed to be the result of trade-offs between different attributes due to preferences for ease of use, for being fully informed and for not being pushed into particular food choices (Grunert & Wills, 2007). Also the possibility to evaluate the potential use of existing and new label formats or combination of label attributes that are not yet available in the market, made discrete choice experiments of interest.

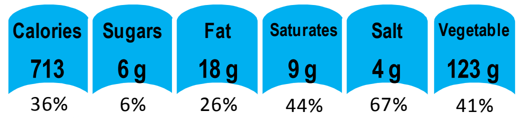
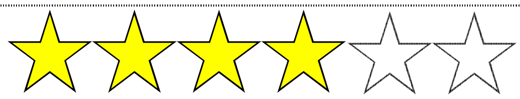
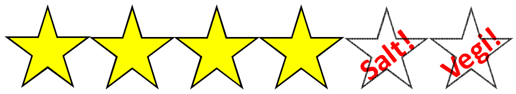
The chapter is structured as follows. The second section describes the design of the choice experiment in detail including the attribute selection, choice design and modelling approach followed in the analysis. The third section presents the results of the choice model. The final section contains a discussion of the results and concluding policy implications of the model outcome.

8.2 Methodology

8.2.1 Attributes and choice experiment design

Choice experiments are widely recognised as a method to reveal preferences of people (Hensher et al., 2005; Louviere et al., 2000; Train, 2003). It is a method that can be used for different applications. Own applications include the choice for water-pricing systems among farmers (Veettil et al., 2011) or more relevant for this study the importance of health and environmental attributes in the buying decision of organic foods (Mondelaers et al., 2009b). In the present study, a choice experiment (CE) was used to assess students' preferences for different labelling formats of nutrition information for canteen meals and to identify factors that explain differing preferences (*see* section on Determinants of choice preferences). Next to the price, the following formats of nutrition information were included in the experiment: GDA information, star-rating information and price (Table 8.1). First, two types of GDA labels – the most widely used on-pack simplified nutrition label in Europe (Storcksdieck genannt Bonsmann et al., 2010b) – were used. The GDA label providing the total amount of energy (kcal) and nutrients (grams) and as a percentage of what a typical healthy adult should be eating daily on the basis of a 2000 kcal diet, was selected as the example of a non-directive, complex and detailed nutrition label (CIAA, 2008). The energy GDA label was included as the example of a non-directive, less complex and basic nutrition label. Second, two types of star-rating labels were used, as examples that provide directive and (more) simple information. A distinction was made between the basic star-rating label, presenting only stars, and a more detailed star-rating label providing additionally a verbal descriptor to signal the high nutrient contents. Because directive nutrition labels give an interpretation of the nutritional quality of the overall product, their processing load would be considerably reduced (Scott & Worsley, 1994). Third, the price vector selected, reflected the current price levels of a pasta dish in the university canteens with the upper bound of 3.50 €. A pasta dish was used as the carrier canteen meal, due to its popularity and frequent availability in the university canteens. A summary of the attributes and levels is provided in Table 8.1.

Table 8.1 Attribute and attribute levels in the choice experiment

Attribute	Levels considered	Example
GDA information	Basic (energy)	
	Detailed (energy, sugar, fat, saturated fat, salt, vegetable)	
	None	
Star rating	Basic (without verbal descriptor)	
	Detailed (with verbal descriptor)	
	None	
Price	3.00 €	
	3.25 €	
	3.50 €	

The basic idea of CE is that an individual derives and maximizes utility from the characteristics or attributes from the goods they purchase or consume rather than from the goods as such (Lancaster, 1966). Based on the Random Utility Theory (McFadden, 1974) and the characteristic theory of Lancaster (1966), the utility for an individual *n* derived from label alternative *i* in choice occasion or set *j* is divided into a non-stochastic (V_{nij}) and stochastic component (ε_{nij}). The non-stochastic utility consists on its turn of a choice-specific utility component (X_{nijl}) and an individual-specific component (Z_{nk}):

$$U_{nij} = V_{nij} + \varepsilon_{nij} \qquad \text{where } V_{nij} = \sum_{l=1}^{5} \beta_l X_{nijl} + \sum_{k=1}^{8} \delta_k Z_{nk} \qquad \text{(Eq. 1)}$$

With *l* is the attribute level (e.g. basic GDA), *i* is the label alternative, *j* is the choice between label alternatives, β_l is the relative utility weight (part-worth utility) associated with attribute level *l*, and *k* is the number individual-specific variables. A widely used approach to estimate the regression coefficients $\theta \in (\beta,\delta)$ is the maximum likelihood estimation, which provides the value for the coefficients that makes the observed results the most probable (given the model). When assuming a basic Multinomial Logit (MNL) model, the θ coefficients can be calculated as follows:

$$\mathrm{LogL}(\theta) = \sum_{n=1}^{1725} \sum_{l=1}^{5} \sum_{j=1}^{6} y_{ijn} \log\left(\frac{\exp(V_{nij})}{\sum_{m=1}^{M} \exp(V_{nmj})}\right) \qquad \text{(Eq. 2)}$$

where y_{ijn}=1 if individual *n* chooses label alternative *i* in choice *j* containing *M* possible choices, and y_{ijn}=0 otherwise.

CE are typically framed in a manner that closely resembles actual purchase decisions (Louviere et al., 2000). An important advantage of the CE methodology, more specific the stated preference experimentation, is that it offers the possibility to analyse the valuation of new products with new attributes for which there is no revealed preference history. By allowing the consumers to value multiple attributes simultaneously, a near market situation is created. While most CE focus on preferences for physical attributes, the CE here explores preferences for information attributes.

Since the full factorial design with three variables, each with three attribute levels (3x3x3), is undesirable, an optimal nonlinear design accounting for two-way interactions between information attributes was used. These interaction terms allow the assessment of potential information overload. The optimal design (using D-efficiency criterion) was created using SAS macros (please refer to Kuhfeld (2009) for details of the SAS macros). The obtained design of 18 choice sets was blocked into three subsets of six choice sets to avoid response fatigue and to keep the survey design controllable. Each choice set contained three alternative labels: two unlabeled alternatives and one ‘opt-out’ choice. The opt-out option captures the preferences for other labelling options not shown in the choice set as well as for a no-buy option. Inclusion of this no-buy option has been recommended by several authors (Adamowicz & Boxall, 2001; Louviere et al., 2000). This is also in agreement with real market decisions where consumers can choose not to purchase or to purchase something else, or purchase elsewhere (Enneking, 2004; Hu et al., 2004). A sample choice card is included as Figure 8.1.

Choice set 1

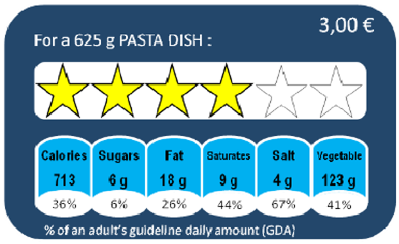
<table>
<tr><th></th><th>Label A</th><th>Label B</th><th></th></tr>
<tr><td></td><td>
</td><td>
</td><td>Neither label A nor label B</td></tr>
<tr><td>Which label do you prefer? (please check)</td><td>☐</td><td>☐</td><td>☐</td></tr>
</table>

Figure 8.1 Sample choice card

In order to obtain an almost equal number of participants in each subset, participants were assigned to one of the three subsets based on their birthday month. For example, all participants born in January, February, March or April received subset 1. Prior to the choice question, the functioning of the choice experiment was explained to the participants defining the labelling attributes and levels included in the experiment. An important facet of the description of the CE task was that their choice or preference did not have to reflect the meal they wanted to eat (all meals were the same), but the label presenting best the desired information.

8.2.2 Determinants of choice preferences

Individual differences in terms of liking of various labelling formats are assumed to be driven by conflicting preferences for simplification, for being fully informed and for not being pushed into particular food choices. These factors are so-called determinants of liking of different nutrition label formats (Grunert & Wills, 2007; Storcksdieck genannt Bonsmann et al., 2010a). All three determinants were measured using several items on a 7-point Likert scale ranging from “totally disagree” (= 1) to “totally agree” (= 7).

The *desire for simplicity* was assessed by four items adapted from the inversed scale of the need for cognition construct (Cacioppo et al., 1984) (e.g. “I would rather do something requiring less thought than something that challenges my thinking abilities”). Need for cognition is defined as the tendency to seek out and enjoy thinking, or also to enjoy engaging in effortful information processing (Cacioppo & Petty, 1982). The internal reliability (Cronbach’s alpha) of the four items was 0.84, denoting good internal consistency. It was hypothesized that people who prefer simplification will like the star-rating labels more than the GDA labels, especially more than the detailed GDA format, since processing of the star-rating labels is limited to the number of stars and verbal descriptor and does not require numerical comparisons.

The *desire for full information* was measured using five items adapted from the construct of interest in information (Verbeke et al., 2008a) (e.g. “If there was a computer in the university restaurant that could supply me with more nutrition information about the meals, I would use it”. Following internal reliability check (Cronbach’s alpha = 0.82), the construct of desire for full information was computed as the average of the five items. Individuals with a preference for full information were expected to favour the GDA labels over the star-rating labels, in particular the basic star-rating format.

For the measurement of the *desire for not being coerced into particular food choices*, four items were adapted from the construct of perceived manipulative intent presented by Cotte et al. (2005) (e.g. "Nutrition information on a food label that tries to persuade people seems acceptable to me"). The average of the four items was calculated given the satisfactory reliability coefficient (Cronbach's alpha = 0.83). The numerical information provided by GDA labels was expected to give less impression of paternalism than does a star rating, especially if accompanied by a verbal descriptor (for the non-complying nutrient) in a red font and followed by an exclamation mark.

The ability to process the nutrition labels was evaluated based on participants' *objective understanding* of the GDA information (adapted from Grunert et al. (2010)), and of the stars in combination with the different verbal descriptors on the detailed star-rating labels. A score was computed for both label formats separately based on the number of correct answers to multiple-choice questions. The higher the score, the better participants understood the information. Previous research suggests that liking and understanding of nutrition labels do not necessarily match (Feunekes et al., 2008; Levy et al., 1992, 1996). For example in the study of Feunekes et al. (2008), stars scored highest on comprehension and liking among four labelling formats, while the GDA scored lowest on comprehension but second highest on liking. Because both liking and understanding of a label are considered important determinants of the use of that label, providing consumers with nutrition information that is generally understood and presented in a preferable format is more likely to result in a higher use of the information and healthier food choices.

Participants' *motivation to process nutrition information* about the canteen meals was assessed using four items on a 7-point Likert scale (e.g. "I would like to receive nutrition information about the meals in the university restaurant") drawn from Keller et al. (1997) and Moorman (1990). Cronbach's alpha for the four-item measure was 0.96, indicating very good internal consistency reliability. Consumers with a higher motivation to process information are more likely to spend time and effort in processing it (Petty & Wegener, 1999), making more detailed labelling formats such as the detailed GDA format of more value to consumer with a higher motivation to process. While consumers with lower motivation to process may prefer the most easily accessible information (e.g. number of stars) and ignore the detailed information (Keller et al., 1997).

Because *women* and *older* consumers in general are more motivated to consider nutrition information in their food choices (Drichoutis et al., 2006; Grunert & Wills, 2007), more detailed label formats like the detailed GDA are expected to be preferred more by women versus men, and by older versus younger consumers.

The complete list of scales and scale items used are presented in Appendix II.

8.2.3 Model specification and estimation

It was assumed that each individual chooses his or her most preferred label from three options (two labels and the opt-out option) based on the presentation of the GDA information, star-rating information and the price (Base model). In a second or full model the impact of determinants of liking and use as well as gender and age on label preferences was assessed. For this purpose, the following non-stochastic utility function was specified (Eq. 3):

$$\begin{aligned} V_{nij} = {} & \beta_1 \mathrm{BasicGDA} + \beta_2 \mathrm{DetailedGDA} - (\beta_1 + \beta_2)(\mathrm{NoGDA}) + \beta_3 \mathrm{BasicStar} + \beta_4 \mathrm{DetailedStar} \\ & - (\beta_3 + \beta_4)(\mathrm{NoStar}) + \beta_5 \mathrm{Price} + \beta_6 \mathrm{BasicGDA} \times \mathrm{BasicStar} + \beta_7 \mathrm{BasicGDA} \\ & \times \mathrm{DetailedStar} + \beta_8 \mathrm{DetailedGDA} \times \mathrm{BasicStar} + \beta_9 \mathrm{DetailedGDA} \times \mathrm{DetailedStar} \\ & + \sum_{k=10}^{49} \delta_k Z_{nk} \end{aligned}$$

where V_{nij} is the estimated utility that participant *n* derives from the attributes of label alternative *i* in a choice occasion *j*. The coefficients β1-β5 in Eq. 3 describe the main effects of the different labelling options, while the coefficients β6-β9 represents the interaction effects between the information attributes in order to check for effects of information overload or information insufficiency. The coefficients δ10-δ49 capture the differences in preferences based on the individual-specific variables considered.

The information attributes were coded using effects coding: basic information was coded 1 and 0, detailed information was coded 0 and 1, and no information was coded -1 and -1. All other variables were included in the model as a continuous variable except gender (with 1 = male and 2 = female) and objective understanding of the GDA (with 0 = no and 1 = yes). To estimate both the base (β1-β9) and full model (β1-β9, δ10-δ49) in Eq. 2, a MNL model was applied, which assumes that individuals are homogeneous in terms of taste in the population (McFadden, 1974). The MNL models were estimated using NLOGIT 4.0 (Econometric Software Inc., Plainview, NY, USA).

Once the regression coefficients were obtained, the mean willingness-to-pay (WTP) for the different attributes were calculated as the ratio of the coefficient associated with the attribute of interest to the price coefficient multiplied by minus one. A marginal WTP for including an additional attribute on the label conditional on the presence of another attribute was assessed by adding the coefficient of the interaction term between both attributes to the coefficient of the initial attribute divided by the negative price coefficient. WTP for attribute bundles was calculated similarly but using the sum of the coefficients of involved attributes and the interaction between both attributes in the numerator. WTP values may be interpreted as the price premium that an individual would be willing to pay to obtain the attribute (bundle) (i.e. nutrition information in a certain format) while keeping total utility constant.

8.2.4 Data collection and sample

Data were collected through a web-based survey and choice experiment among students of Ghent University, Belgium, in February 2010. All BSc, MSc and PhD students enrolled at Ghent University during the academic year 2009-2010, were invited to participate in the survey by e-mail with a link to the web-based survey. In total, 1725 responses were returned and have been used for further data analysis. The socio-demographic profile of the sample is presented in Table 8.2. The majority of participants was female within the age group 17-25 and undergraduate (BSc) student. The large number of female participants corroborates with the finding that women show greater interest in diet and health issues (Wardle et al., 2004). It is important to note that the specificity of the sampling frame does not allow generalisation to other populations. A preliminary version of the questionnaire was pilot-tested in a small sample of 30 students for clarity of content and overall understanding of the survey.

Table 8.2 Sample characteristics (%, n = 1725)

		Percentage (%)
Socio-demographic characteristics		
Gender	Male	32.8
	Female	67.2
Age	17-20 years	28.8
	21-23 years	39.4
	23+ years	31.8
	Mean (SD)	23.0 (4.0)
Education (completed)	Undergraduate: BSc student	47.7
	Graduate: MSc student	33.4
	Postgraduate: PhD student	18.8
Attitudinal variables		
Likingsimple[1]	Mean (SD)	2.6 (1.1)
Likingfull[1]	Mean (SD)	3.1 (1.3)
Likingncoercive[1]	Mean (SD)	3.9 (1.4)
Motivation[1]	Mean (SD)	4.9 (1.6)
UnderstandGDA[2]	Mean (SD)	1.0 (0.2)
UnderstandStar[3]	Mean (SD)	5.7 (1.7)

[1] measured on a 7-point scale
[2] measured as a score on 1
[3] measured as a score on 7

8.3 Results

8.3.1 Base model with choice specific variables

Participants chose either of the presented labels in 89% of the cases instead of the opt-out option (11%), indicating that in general they derived a higher utility from choosing a meal with nutrition information than without. The results for the base MNL model, which include the main effects as well as two-way interactions between the choice-specific nutrition information attributes (Table 8.1), are reported in Table 8.3. In congruence with the standard economic theory, the effect of the price on utility was negative indicating that price increments decreased consumers' utility. The positive value of the parameter estimates for each of the information attributes except for the basic star-rating format, confirmed that the utility of a meal was higher with than without nutrition label. The negative value of the parameter estimates for the interactions between the basic formats of the GDA and star-rating label (basicGDA x basicStar), and between the detailed formats of both label types (detailedGDA x detailedStar), indicated that the utility for the joint provision of respective label formats was less than the sum of utilities derived by each of the label formats individually. In other words, participants experienced a decreasing marginal utility from the combinations of the two simple label formats as well as from the two detailed formats. The first result might signal perceived information insufficiency, while a combination of detailed information may become too complex, thus indicating some tendency of information overload. The non-significant interaction between basic and detailed label formats (basicGDA x detailedStar, detailedGDA x basicStar) indicated that the effect on utility of providing both information was equal to the sum of the utilities associated with the presence of each label format in isolation. Since this utility was higher than that of the combinations of basicGDA x basicStar and detailedGDA x detailedStar, participants preferred a joint provision in between these two (i.e. combination of a detailed and a basic format). WTP measurement also proved this finding.

Table 8.3 Parameter estimates of the base and full MNL model

	Base model		Full model	
Variable	Coefficient	SE	Coefficient	SE
BasicGDA	0.186**	0.019	0.197	0.188
DetailedGDA	0.496**	0.018	-0.048	0.198
BasicStar	-0.091**	0.019	0.458*	0.201
DetailedStar	0.177**	0.020	-0.601**	0.198
Price	-0.931**	0.050	0.330	0.362
BasicGDA x BasicStar	-0.105**	0.041	-0.104*	0.042
BasicGDA x DetailedStar	0.073	0.041	0.090*	0.042
DetailedGDA x BasicStar	-0.047	0.038	-0.039	0.039
DetailedGDA x DetailedStar	-0.197**	0.034	-0.208**	0.036
Likingsimple x BasicGDA			0.003	0.017
Likingsimple x DetailedGDA			-0.058**	0.018
Likingsimple x BasicStar			0.040*	0.018
Likingsimple x DetailedStar			0.029	0.018
Likingsimple x Price			-0.034	0.034
Likingfull x BasicGDA			-0.051**	0.019
Likingfull x DetailedGDA			0.156**	0.021
Likingfull x BasicStar			-0.012	0.021
Likingfull x DetailedStar			-0.016	0.020
Likingfull x Price			-0.129**	0.038
Likingncoercive x BasicGDA			-0.011	0.014
Likingncoercive x DetailedGDA			0.022	0.014
Likingncoercive x BasicStar			-0.020	0.015
Likingncoercive x DetailedStar			-0.020	0.014
Likingncoercive x Price			0.059*	0.027
Motivation x BasicGDA			0.016	0.015
Motivation x DetailedGDA			0.134**	0.016
Motivation x BasicStar			-0.056**	0.016
Motivation x DetailedStar			0.041**	0.016
Motivation x Price			-0.217**	0.029
UnderstandGDA x BasicGDA			0.008	0.086
UnderstandGDA x DetailedGDA			-0.096	0.090
UnderstandGDA x BasicStar			0.019	0.091
UnderstandGDA x DetailedStar			0.098	0.090
UnderstandGDA x Price			0.031	0.166
UnderstandStar x BasicGDA			-0.012	0.011
UnderstandStar x DetailedGDA			-0.044**	0.012

Continued

*for p < 0.05, ** for p < 0.01

SE: Standard error

Table 8.3 Continued

	Base model		Full model	
Variable	Coefficient	SE	Coefficient	SE
UnderstandStar x BasicStar			0.007	0.012
UnderstandStar x DetailedStar			0.073**	0.012
UnderstandStar x Price			-0.053*	0.021
Gender x BasicGDA			0.230**	0.039
Gender x DetailedGDA			-0.188**	0.041
Gender x BasicStar			0.037	0.042
Gender x DetailedStar			-0.031	0.041
Gender x Price			-0.105	0.076
Age x BasicGDA			-0.010*	0.005
Age x DetailedGDA			0.008	0.005
Age x BasicStar			-0.018**	0.005
Age x DetailedStar			0.007	0.005
Age x Price			0.019*	0.009

*for $p < 0.05$, ** for $p < 0.01$

SE: Standard error

In order to fully understand participants' valuation of different labelling options, the mean willingness-to-pay (WTP) estimates for each choice-specific attribute (main effects) and the attribute bundles (interaction effects) as well as the marginal WTP for attribute inclusion conditional on the presence of another attribute were calculated and are presented in Table 8.4. Results indicate that participants in our catering setting placed the highest value on the detailed GDA format, which is the most widely used simplified nutrition label on prepacked foods. The average premium that the participants were willing to pay for detailed GDA information about the canteen meal is 0.53€ (18% price premium). Participants also attached positive WTP to the provision of basic GDA information (0.20€) and detailed star-rating information (0.19€).

From the marginal WTP estimates, it is clear that the presence of other attributes influenced consumers' valuation of a certain attribute. Of all combinations between GDA and star-rating information, the joint provision of the basic GDA and detailed star-rating information was the only combination that marginally increased the WTP. In other words, the total value of this combination (total WTP = 0.47€) was higher than the sum of the individual attribute effects (sum of mean WTP = 0.39€). When both detailed label formats were provided jointly, the WTP marginally decreased with 0.21€, indicating a situation of information overload that was perceived negatively. However, this combination of information was associated with the second largest premium or 0.51€ because of the high value of the detailed GDA information (i.e. 0.53€), making this combination not the desirable one. Finally, the participants disliked the provision of information in the form of a number of stars without description (i.e. Basic star-rating label), either in isolation (a decrease of mean WTP by 0.10€) or together with the basic GDA information (a decrease of total WTP by 0.01€). From these results it appears that the detailed GDA information in isolation or the combination of basic GDA and detailed star-rating information were the preferred ways of communicating the nutritional profile of the meals.

Table 8.4 Willingness-to-pay (WTP) estimates (in €) for each information attribute conditional on the presence of zero or one related attribute

Attribute	In combination with…		
	None	*BasicStar*	*DetailedStar*
Basic GDA	0.20	0.09	0.28
Detailed GDA	0.53	0.48	0.32
	None	*Basic GDA*	*Detailed GDA*
Basic Star	-0.10	-0.21	-0.15
Detailed Star	0.19	0.27	-0.02

Note: Total WTP for attribute 1 x attribute 2 is the sum of the marginal value of attribute 2 appearing jointly with attribute 1 and the marginal value of attribute 1 appearing in isolation (e.g. Total WTP of BasicGDA x DetailedStar = 0.20 + 0.27 = 0.19 + 0.28 = 0.47€)

8.3.2 Full model with choice specific and individual specific variables

The full model including individual characteristics as explanatory variables related to liking and use of a label is described in Table 8.3. A similar overall effect of choice-specific variables in both models was obtained when conditioned upon interaction terms. The results of the full model show that in general the considered determinants of liking and use were statistically significant when interacted with the choice attributes and thus clearly affecting consumers' utility. With respect to the overall fit, the full model was superior to the base model (likelihood ratio test yields a $p < 0.001$).

When looking at the role of the three dimensions of liking in explaining utility, it should be noted that the third dimension or the desire for not being coerced into particular food choices, did not significantly interact with any of the information attributes. It means that this dimension did not add to the explanation of participants' label preference. In particular, the directive star-rating labels appeared not to have a negative impact on the utility experienced by participants with a desire for not being pushed in certain choices. Individuals with a preference for simplification valued the basic star-rating label higher than no information, but at the same time they derived less utility from detailed GDA information. Among this group there is a clear tendency of avoiding more detailed and complex information on nutrition labels, consistent with our hypothesis. A preference for full information was associated with a lower utility from the basic GDA format compared to no information, while the detailed GDA format was highly valued. Individuals with a preference for being fully informed attached no significant value to both star-rating labelling formats. For this group the price seemed to be more important than for the group that dislikes being coerced into making certain choices.

None of the interactions between objective understanding of the GDA information and the information attributes were significant, suggesting that the degree of understanding GDA may not predict label preferences. This could be explained by the fact that 95% of our sample knew how to interpret GDA. Although the average objective understanding of the detailed star-rating labelling concept was also high with a mean score of 5.7 on 7, understanding of this concept was more heterogeneous within the sample. The positive value of the parameter estimate for the interaction with the detailed star-rating format indicated that the associated utility was higher with a higher level of understanding of this format. At the same time, those with a higher understanding of the detailed star-rating format seemed to value the detailed GDA format less than no information.

A higher motivation to process nutrition information provided with canteen meals had a positive impact on the valuation of both the detailed GDA and the detailed star-rating label, but a negative impact on the basic star-rating label. Female participants obtained more utility from the basic GDA label than male participants, but less utility from the detailed GDA with reference to no information. That is, while making a choice preference, females preferred basic GDA whereas males preferred detailed GDA. The information overload was more vivid in female participants than male participants, thus opting for simple information. Additionally, gender did not explain the preferences for the star-rating formats. Increasing age had a negative impact on the utility associated with basic label formats and no impact on the valuation of the detailed label formats. For the older age group of this student sample, which consisted mostly of PhD students having the highest education, a dislike of basic and thus less informative nutrition labelling formats matched expectations. The positive value of the parameter estimate for the interaction between age and price indicated that the utility of price increments was higher with increasing age. This may be explained by the fact that PhD students have an income which is not the case for most undergraduate students.

8.4 Discussion and conclusions

A nutrition label that is generally understood and presented in a preferred format is more likely to be used and to affect food choices among its target population (Grunert & Wills, 2007). Because university students rely regularly on university canteens for their main meal (CMM UGent, 2009), simplified nutrition labelling could be a promising policy tool to promote healthier diets in a large population if both conditions of liking and understanding of the label are met. Therefore, the present study aimed to identify students' preferences for different labelling formats of nutrition information for canteen meals and to explain preference heterogeneity based on determinants of liking and use of nutrition labels. Results indicate that students generally valued the presence of simplified nutrition labels on canteen meals. The detailed GDA label was found to be the most preferred label format, which is also the most widely used simplified nutrition label on prepacked foods (Storcksdieck genannt Bonsmann et al., 2010b). This may confirm that familiarity with the label (from experience in the retail market for food consumption at home) is another determinant of label preference (Möser et al., 2010). Signals of information insufficiency and information overload were observed when providing students with increasing levels of simple (or basic) information and increasing detailed information, respectively. When opting to combine labelling formats, the best combination would be one of basic GDA information with detailed star-rating information together. Students disliked the provision of too simplistic and low informative information such as a number of stars without further description or explanation (or basic star-rating information). Students' ability and motivation to process the information as well as gender and age explained differences in label preferences. Regarding the three dimensions of label liking, label preferences were found to be significantly determined by the desire for simplicity and by the desire for full information, but not by the desire for non-coerciveness. This means that more directive labels such as stars (with or without descriptor) were acceptable to the majority of canteen customers, i.e. these labels were not perceived negatively as imposing or forcing meal choice in a particular direction. Highlighting the nutritional shortcomings of a meal on the label may nevertheless be unacceptable to many caterers (Lachat et al., 2011), herewith entailing a potential limitation to the practical usefulness of the label in voluntary programs.

The reported findings have relevant implications for canteen customers, public and private organisations dealing with food and health policy. Because simplified nutrition labels are expected to reduce search and information costs, better informed and healthier food choices may be facilitated which may eventually lead to healthier consumption patterns and a favourable health outcome. However, the more detailed formats among the simplified nutrition labels may not affect the individuals who especially need to change their food choice behaviour, e.g. for medical reasons (Berning et al., 2007). Based on our results, less motivated canteen customers with a preference for simplified information were more likely to use the labels that required relatively less time and effort to process, such as the basic GDA and the detailed star-rating label. Customers who preferred more detailed labels may on their turn be underprovided of information when presented with too simple labels. In order to satisfy most customers' information needs, a more successful labelling strategy could be the combination of both the basic GDA and the detailed star-rating information given that this was the most valued combination. In that case, it will be important to increase the understanding of the detailed star-rating concept in the general sample, since a better understanding leads to a higher valuation of this labelling format. As such, information asymmetry between canteen customers and private or public organisations may be reduced (Verbeke, 2005). Of relevance for caterers is the guideline for the nutrition label to be used on their canteen meals. Additionally, given the presence of these nutrition labels, canteen customers may effectively signal their preferences for nutritional quality through their purchase. This allows caterers and indirectly also the meal component and ingredient suppliers to adapt their food offer based on their customers' food preferences, e.g. more low-energy or low-sodium meals. Mandatory instead of voluntary simplified labelling of canteen meals is expected to increase market performance since meal components with unfavourable nutritional profiles and labels may either be removed from the menu or may be subjected to product reformulation (Rubin, 2008). The caterer himself may opt to change suppliers. For public policy it will be important to identify different consumer segments according to their label preferences and to profile these segments based on the considered determinants of label use among others (e.g. body mass index).

While the study provided new insights about the valuation of nutrition labels for canteen meals in a sample of Belgian students, future studies are recommended to investigate whether these findings hold equally in other European countries and among non-student populations. For example, the study by Möser et al. (2010) observed a difference in labelling preference between Belgium and Germany. Whereas most consumers in Belgium indicated a preference for the GDA, in Germany the TL was favoured most.

The main strengths of this study pertain to its controlled setting and the large and relevant sample. To our knowledge, it is the first study that addresses preferences for simplified nutrition labels in an OH setting which is becoming increasingly important as food choice environment (Orfanos et al., 2007; Vandevijvere et al., 2009). The focus on young adulthood is justified by the increased recognition of this age group as a target for health promotion and disease prevention since the majority of these young people have to start making food choices for their own or for their young families (Nelson et al., 2008). The habits they develop at this stage in their lifecycle are possibly crucial for their later personal and family life. The use of a web-based survey is considered appropriate for this computer literate population; apart from the advantages of being cost effective, reducing the turnaround time and enhancing survey item completion rates are important assets of the method (Schleyer & Forrest, 2000).

Nevertheless, the study also faces some limitations, which open up opportunities for further research. Firstly, the study evaluated only two types of simplified nutrition labels in the specific setting of canteens using one product (i.e. a standard pasta dish). Future research could explore the valuation of other nutrition labels in a wider range of FAFH products, different settings (e.g. fast food, workplace canteens, restaurants, hospitals, schools) and age groups. A comparison between different products varying in perceived healthiness and degree of familiarity would be interesting since diverse products may elicit different responses to nutrition (Barreiro-Hurle et al., 2008; Grunert & Wills, 2007), e.g. some foods may rather be chosen for satisfying a predominant nutrition motive, whereas others may rather be chosen to satisfy hedonic motives. Also the setting of food choice might influence consumers' response to nutrition labelling (Kozup et al., 2003; Seymour et al., 2004). As consumer organisations are aiming at the same labelling scheme on prepacked foods, foods sold loose and foods sold through catering outlets (BEUC, 2006), a comparison of labelling format preferences across these different settings would be desirable. Regarding the selection of information attributes, the choice design could include additional attributes related to the nutrients to be presented and the reference quantity to be used. Previous research indicated that different nutrients are not valued to the same extent (Balcombe et al., 2010; Hoefkens et al., 2011b). As with other nutrients there is still a lot of ongoing discussion on whether the energy content should be expressed in absolute terms or relative to recommended daily intake, or whether it should be expressed per serving or per 100 g (van Kleef et al., 2008). The inclusion of more attributes could certainly add reality to the experiment, but with a potential risk of preference elicitation in a complex choice setting which can lead to bias in elicitation process. A third limitation pertains to the possible presence of hypothetical bias due to the reliance on stated rather than on revealed preferences for model estimation. A study by Drichoutis et al. (2009) used experimental auctions to assess whether consumers value nutrition labels for FAFH products. This method has the advantage that it is conducted in a non-hypothetical context involving real products, real money and a bidding technique compared to the CE approach. A disadvantage of experimental auctions is the restriction of choice sets to existing products and product attributes. Although several studies have reported a good match between the results obtained from choice experiments and actual behaviour or revealed preferences (Adamowicz et al., 1998; Adamowicz et al., 1994; Adamowicz et al., 1997), non-hypothetical settings are closer to the real living and choice environment facing consumers.

In conclusion, the presentation format of nutrition information played a decisive role on students' valuation of nutrition labels for canteen meals. Individual variables such as students' personal motivation and ability to process the information and socio-demographic characteristics contributed to the explanation of the observed differences in label preferences. More detailed nutrition labels such as basic GDA-type of numerical information in combination with interpretational visual aids like stars or colour codes are proposed for future use in university canteen settings. Although the implementation of simplified nutrition labels on FAFH may be a step in the desired direction of more healthy food choices, nutrition labelling as such is unlikely to solve the problem of overweight and obesity. It should be seen as one of the policy instruments to be used in public health initiatives, programs and food-related policies for combating obesity.

PART IV

General discussion and conclusions

The previous two parts have presented study-specific findings and discussed implications in detail. This final part (Part IV) provides a general discussion of the main findings and conclusions in light of the proposed conceptual framework presented in Chapter 1 (Part I). The first section (9.1) recapitulates the research procedure and revisits the research hypotheses outlined in Chapter 1 in response to the research objectives. The second section (9.2) provides a general discussion of the main research findings and their implications for the food production and distribution sector, food service or catering sector and public health authorities. The third and final section (9.3) acknowledges the limitations of this doctoral research and proposes perspectives for further research.

9.1 The research objectives and hypotheses revisited

The overall objective of this doctoral research was to improve the understanding of the role of information in consumers' health-related food quality perceptions and their food choices. A better understanding of this quality perception process contributes to the development of better nutrition and health communications and as such hopefully to better informed and healthier food choices and diets. Two case studies were conducted to address the objective, one dealing with organic vegetables, the other with nutrition information on meals in university canteens. Both case studies covered specific elements of the conceptual framework using a multidisciplinary quantitative research approach, i.e. a literature-based comparison of nutrient and contaminant content data (Study 1), several quantitative consumer surveys (Study 2, Study 4 pre-post), an intake assessment study (Study 3), and a web-based choice experiment (Study 5). All studies were conducted in Flanders, Belgium, among (young) adults in the period of 2006-2010. Based on the conceptual framework, four specific research objectives (two objectives per case study) and eight research hypotheses were formulated, which are discussed in the following subsections.

9.1.1 Exploring the gap between scientific evidence and consumer perception regarding the nutritional value and safety of organic versus conventional vegetables

This first objective has been dealt with in the first two chapters of Part II. The science-based evidence on differences in nutrient and contaminant content between organic and conventional vegetables was covered in Chapter 3. This chapter described the development of detailed nutrient and contaminant databases for organic and conventional vegetables as well as the statistical results of the differences in nutrient and contaminant content between both cultivation methods (Study 1). Chapter 4 reported consumers' perception towards the nutritional value and safety of organic versus conventional vegetables (Study 2) and discussed the agreement between the facts and consumer perceptions.

Using the concepts of the framework in Chapter 1, Chapter 3 dealt with the objective quality of vegetables including the product-oriented (nutrient and contaminant content) and process-oriented quality (organic production), while Chapter 4 reported on the subjective or perceived quality of organic versus conventional vegetables. Both the nutrient and contaminant content, and the cultivation method are intrinsic and credence quality attributes. However, these attributes are transformed into search attributes when information is provided. Since vegetables do not contain nutrition and contamination information on pack provided they are packed at all, the only information consumers may rely on when making food choices is whether or not they have been grown organically. Two hypotheses were drawn based on the conceptual framework presented in Figure 1.3 (p. 11). First, consumers use the organic claim as an extrinsic quality cue to assess the health-related quality of vegetables. Second, the objective health-related quality (i.e. nutritional value and safety) does not match consumers' perceived quality of vegetables.

The results of the profound literature-based comparison in Chapter 3 revealed that the scientific evidence up to 2009 could not univocally state that organically grown vegetables are healthier (i.e. richer in beneficial nutrients and poorer in harmful contaminants) than conventionally grown vegetables (**H1 partly confirmed**). Inconsistent findings with respect to differences in vitamins, minerals and beneficial phytochemicals were found between organic and conventional vegetables. Additionally, the generally higher contents of synthetic pesticide residues and nitrates observed in the conventional food, were still far below the statutory maximum amount and as such not posing any health risk. Moreover no trend was observed for the heavy metals (cadmium and lead). The finding of no difference in nutritional quality between organically and conventionally produced foods has recently been confirmed by a systematic review (Dangour et al., 2009). Product-related and place-related factors other than the cultivation method (cf. Conceptual framework) may be more important determinants of the highly variable nutrient and contaminant composition of vegetables, for example the cultivar of the vegetable, the quality of the environment (air, water, soil, climate), pest and disease incidence, and post-harvest practices (like storage and home preparation) (Holden, 2002; Rembialkowska, 2007; Zhao et al., 2006).

Chapter 4 indicated that organic vegetables benefit from more favourable consumer perceptions compared to conventional vegetables. Consumers perceived organic vegetables as containing less contaminants and more nutrients, and as such, as being healthier than conventional vegetables. The first hypothesis that consumers associate health-related qualities of vegetables with the organic claim is confirmed (**H2 confirmed**). Consumers considering organic vegetables to be healthier than conventional vegetables also perceived the organic product as having less contaminants, more nutrients, no pesticide residues, less mycotoxins, less harmful micro-organism and as being safer. Consumers gave relatively more credence to the health benefit of less contaminants than to the benefit of more nutrients. This finding should not be surprising, given that unfavourable communication related to food-health issues weigh more heavily in consumers' food consumption decisions than favourable news (Richey et al., 1967; Verbeke & Viaene, 2001).

The results of the literature-based comparison of the nutritional value and safety between organic and conventional vegetables in Chapter 3 together with the findings on consumer perception of the health-related quality of organic compared to conventional vegetables in Chapter 4 confirm the second hypothesis that the objective quality does not match consumers' perceived quality (**H3 confirmed**). Available scientific evidence did not support nor refute the superior health-related quality of organic vegetables, but consumers in general strongly believed in the health advantage of organic over conventional vegetables. The gap between facts and perception appeared to be the largest for the health character, the nutritional value and microbiological safety, which are the food aspects with major inconsistent results. The mismatch was also stronger with increasing age and a higher consumption frequency, but independent of gender, place of residence, education and income level. Given the lack of scientific evidence arguing in favour of organic health-related credence qualities, consumers tend to form subjective quality expectations based on stereotypes, image transfer and emotion instead of factual knowledge (Saher et al., 2006).

9.1.2 Investigating the influence of consumers' health-related perception of organic on the consumption of vegetables

Chapter 5 of Part II has addressed the second objective of the first case study which relates to the person-related factor of the conceptual framework (Figure 1.3, p. 11) and its influence on perceived food quality, which in its turn is assumed to impact the food choice and dietary intake. In Chapter 4 differences in consumers' health-related perception of organic versus conventional vegetables were observed according to the claimed share of organic in total claimed vegetable consumption. Chapter 5 aimed to investigate the influence of consuming organic versus conventional vegetables on the intake of nutrients and contaminants. The results reported in Chapter 5 are based on the intake assessment study (Study 3) which combines the vegetable composition data compiled in Study 1 and the vegetable consumption data collected in Study 2. Two consumption scenarios were considered. In a first scenario the intake of nutrients and contaminants were based on existing vegetable consumption for the

Belgian population (De Vriese et al., 2005) in order to find out whether differences in nutrient and contaminant content between organic and conventional vegetables implied differences in beneficial nutrient intakes and/or safety concerns because of too high contaminant intakes. The second scenario assumed a difference in consumption level between organic and conventional consumers and as such a difference in nutrient and contaminant intake depending on whether an organically or conventionally grown vegetable was consumed.

No implications for public health were found in both scenarios except for a too high nitrate intake through the consumption of organic lettuce in a small percentage of the Flemish population. The general higher vegetable consumption of organic compared to conventional consumers was found to outweigh the role of potential differences in nutrient and contaminant content between organic and conventional vegetables. In Chapter 4 an association was found between the perceived added value for health of organic relatively to conventional vegetables and the organic consumption level. This findings, together with the higher vegetable consumption and consequently higher nutrient and contaminant intakes of organic consumers (Chapter 5), confirm the hypothesis that the perceived food quality is a better determinant of food choice and dietary intake than the objective food quality (**H4 confirmed**). The significant higher consumption of vegetables in the group of organic consumers is explained by the different lifestyle organic consumers often have which involves vegetarianism, active environmentalism, alternative medicine and/or preventative health actions (through diet) (Cicia et al., 2002; Makatouni, 2002).

9.1.3 Evaluating the effectiveness of posting point-of-purchase nutrition information in university canteens on consumers' meal choices and nutrient intakes

Part III of this doctoral dissertation has been devoted to the second case study of which Chapter 6 and 7 dealt with the effectiveness of posting nutrition information in university canteens in helping canteen customers to make healthier food choices. With respect to this specific objective, three hypotheses were drawn from the conceptual framework. First, canteen customers use the nutrition information on meals as an extrinsic quality cue to make healthier meal choices leading to improved nutrient intakes. Second, the effectiveness of the nutrition information in terms of improved meal choices and nutrient intakes depends on whether the nutrition label is liked, understood (i.e. matches the intended meaning) and eventually used. In other words, a better match between objective and perceived nutritional quality of meals is obtained if the scientifically substantiated nutrition label is liked, understood and eventually used. Third, the effectiveness of the nutrition labelling depends on person-related factors such as socio-demographic characteristics, diet-health awareness, food choice motives, motivation to change diet and the level of objective nutrition knowledge.

Both Chapter 6 and 7 were based on the one-group pretest-posttest intervention study (Study 4) including three-day food and physical activity records and quantitative consumer surveys completed at baseline (2008) and follow-up (2009).

The overall effect of the intervention study presented in Chapter 6 revealed that posting nutrition information about canteen meals did not improve canteen customers' meal choice and nutrient intake. Given that the rating system underlying the nutrition label had a good discriminative power, the ineffectiveness of the nutrition-information intervention could only be attributed to the fact that the label was generally not (effectively) used by the participants (**H5 rejected**). The nutritional quality of the meal choice was largely determined by the quality of the total meal offer which met the considered meal recommendations of energy, saturated fat, sodium and vegetable only in about 5% of the cases. Moreover, participants did not compensate for their meal choice later during the day.

In Chapter 7 an explanation for the ineffectiveness of the nutrition-information intervention was sought in consumers' processing of the labelling information starting with the perception of the nutrition label (i.e. extrinsic quality cue). If perceived, it was hypothesized that participants who understand and like the nutrition information, will be more likely to (effectively) use the information, will then increase their subjective knowledge about how to evaluate the healthiness of a food, leading to a more positive attitude towards healthy canteen meals and ultimately to a healthier meal choice. The results obtained through a structural equation modelling analysis confirmed partly the hypothesized hierarchical model for certain subgroups of participants only (**H6 partly confirmed**). Consumers needed to be motivated to change their diet and to have sufficient objective nutrition knowledge in order to maintain a recommended energy intake from canteen meals or to lead to a decrease in energy intake (**H7a confirmed**). Strong associations were found between liking and use of the label, liking of the label and change in attitude, and use of the label and change in attitude. Although consumers' motivation to change diet was primordial to be affected by the nutrition-information intervention to a certain extent, a base level of objective nutrition knowledge seemed necessary to turn one's objective understanding of the label into effective use of the label.

In Chapter 6 some additional person-related factors were investigated which were assumed to impact the effectiveness of the intervention. The expected trade-off between health (credence quality aspect) and sensory motives (experienced quality aspect) in making meal choices in the canteen could not be confirmed, as well as the influence of consumers' diet-health awareness. Also the socio-demographic characteristics gender and age did not influence the impact of the nutrition-information intervention. Participants with stronger health and weight-control motives were more likely to choose a recommended meal. Furthermore, participants being more open to change and as such being less restricted to familiar meal choices were also more likely to follow the meal recommendations. As such, the hypothesis of differences in intervention effectiveness according to person-related factors can be partly confirmed (**H7b partly confirmed**).

9.1.4 Identifying and understanding consumer preferences for alternative nutrition labels on canteen meals

The fourth and final objective based on the conceptual framework was to evaluate the influence of information characteristics (i.e. simplicity, completeness, and (lack of) coerciveness) and person-related factors on consumer label preferences (Chapter 8). Chapter 7 already indicated that individual differences in motivation and objective nutrition knowledge moderated the effectiveness of the nutrition-information intervention. In Chapter 8 an additional explanation was sought in the characteristics of the information implemented. The results of the structural equation model in Chapter 7 already highlighted the importance of consumer liking of the nutrition label as a predictor of label use. Consumer label preferences were analyzed using a web-based choice experiment (Study 5) in which consumers were asked to choose between label formats including information on guideline daily amounts (GDA) and/or star-rating information next to the price. Participants generally valued the presence of nutrition labels on canteen meals and showed a preference for more detailed formats. However, indications of information overload and information insufficiency were observed with increasing detailed information and simple (or basic) information, respectively. Differences in label preferences were found according to participants' preference for simplicity and/or completeness of information but were independent of a dislike to be directed to certain choices (**H8a partly confirmed**). Participants' understanding of the different nutrition concepts (GDA, star rating) appeared to influence their label preference as well. Regarding the person-related factors, a higher motivation to process the nutrition information on canteen meals was associated with a more positive valuation of both detailed label formats and a more negative valuation of the basic star-rating label. A preference for basic versus detailed GDA information was found according to gender, while the age affected the valuation of detailed GDA and star-rating information. This confirms the hypothesis that person-related factors influence consumer label preferences (**H8b confirmed**). Although individual differences in label preferences are acknowledged, the results of the choice experiment among university students suggest a nutrition label for canteen meals containing the energy content relatively to the GDA in combination with familiar interpretational visual aids like stars and colour codes. This label format is proposed as extrinsic quality cue to be used by university students to assess the nutritional quality of meals with the potential to improve their meal choice and nutrient intake.

9.2 General discussion and societal implications

Health-related food qualities – a key priority for food and public health policy – have become of increasing importance for consumer food choice due to the increased public awareness of the diet-health relationship. The rising prevalence of diet-related non-communicable chronic diseases however, suggests that consumers encounter difficulties in making healthier food choices. An important bottleneck is the credence characteristic of the healthiness of a food for which consumers rely on various nutrition and health communication. Without clear, concise and informative communication, information asymmetry between consumers and other stakeholders (food industry, public health authorities, researchers) will remain. In order to develop better consumer communication, understanding the role of information in the way consumers perceive food-health qualities and make food choices is essential. In this regard, presented doctoral research has provided new insights by means of two highly topical cases, i.e. on organic and out-of-home (OH) foods. Based on the results of both case studies, several suggestions for improved consumer communication are presented.

From a scientific perspective, organic labelling for vegetables (**Case study 1**) appears to fail as a health-related quality cue because of the underlying scientific evidence being mostly inconclusive. Where science is more undecided, consumer perception is more often based on non-factual information, in this case mostly of organic food proponents. Their influence on media to promote organic food and this often at the expense of conventional food seems to greatly affect consumer perception which, based on the consumer survey, was found to be clearly in the advantage of organic. This is explained by the fact that consumers attach much more importance to unfavourable information in food decisions. An example of misinformation introduced in the media was the statement that moving to organic food is like "eating an extra portion of fruit and vegetables every day" resulting in messages of "four a day" can suffice instead of the recommended "five a day" (Rosen, 2010).

To overcome misleading consumer communication regarding organic foods, an evaluation and approval process of organic claims similar to that of nutrition and health claims under the EU regulation (EC Regulation 1924/2006) is suggested. Furthermore, given the inconclusiveness of current scientific evidence, public health authorities are proposed to further stimulate vegetable consumption in general and to educate consumers about the beneficial effects of consuming a recommended portion of vegetables per day without differentiating between the organic or conventional origin of the vegetable. From the perspective of the organic vegetable sector, exploiting propositions in their product positioning and communication strategies that are not fully scientifically sound should be avoided. A better communication strategy would be to capitalise rather on emotional value than providing rational argumentation for the choice of organic vegetables. “Organic” should be considered as a process claim, indicating to consumers that a product was produced according to the organic regulation (EC Regulation 834/2007), rather than a product claim (including nutrition and health claims). Finally, further intervention research is required to strengthen scientific evidence about the added value of organic vegetable consumption for health to enable consumers to make decisions based on correct and objective information.

Even when consumer communication is science based, informed food choices cannot be taken for granted, which is illustrated in the second case study dealing with nutrition labelling of canteen meals (**Case study 2**). Person-, information- and product-related factors have shown to influence the effectiveness of the nutrition-information intervention in university canteens. Implications for the food service or catering, food producer and public health authorities are discussed.

First, although consumers reported to attach great importance to the nutritional value of foods in food choices in general (Chapter 2) and to have important health and nutrition motives when choosing a meal in a canteen (Chapter 6), they still lacked motivation and knowledge to actually choose healthier foods and change their eating behaviour. An improved communication strategy would be to use both a generic nutrition label and specifically tailored or personalized information to consumers, particularly to younger consumers. As generic labelling approach, presented doctoral research proposes a combination of simple and more detailed information on canteen meals such as numerical information on the energy content and an overall appreciation of the nutritional quality using familiar visual aids like stars and colour codes. The provision of too much simplistic and too much detailed information should be avoided, since it stands a real risk of information insufficiency and information overload leading to further confusion and ignorance of the information by the majority of consumers. Interactive personalized nutrition communication through the internet and emerging social media on trendy electronic information vehicles is suggested as a promising way to address personal relevance, flexibility and active participation (Bouwman et al., 2005; Brennan et al., 2010; Normand & Osborne, 2010). In order to put this approach into practice, more insights into the interaction between nutrition and human genetics as well as the social acceptance of personalized nutrition communication will be required. Our research has already indicated that more directive labels such as a star rating and indications of nutrient contents in a red font followed by an exclamation mark are generally liked by university students. A potential barrier of this tailored approach could be the bias of commercial nutrition related websites that lack scientific base.

With respect to the meal offer in university canteens, caterers are recommended to invest time and effort to create a healthy eating environment. The catering sector should recognize their role in the promotion and facilitation of healthy food choices. Careful menu planning should be guaranteed to ensure nutrition adequacy and consistency with dietary guidelines without compromising the taste. Our research has indicated that the sensory aspects are major motives for choosing a meal next to the price and health value. Changes in the food supply does not only concern the caterer but also the food producers which may have to reformulate their food products. For both food producers and caterers, providing nutrition information and producing/serving healthy foods which are necessary for consumers to make informed and healthier food choices, is a way to demonstrate good corporate social responsibility and to differentiate themselves from competitors.

Finally, public health authorities are encouraged to not only educate end consumers, but also food producers and caterers about the importance of healthy foods in OH settings. Further emphasis should be placed on social responsibility and collective action to make the healthy choice the easy choice. The catering sector should be more engaged in strategies for healthier eating out in Europe (Lachat et al., 2010). By regulating nutrition and health communication, food reformulation and innovation by food producers should be stimulated (Vyth et al., 2010; Young & Swinburn, 2002). Additionally, food and health policies with regard to nutrition communication should be, as much as possible, consistent for prepacked foods, foods sold loose and in catering outlets in order to contribute to consumers' awareness of the communication and strengthen its impact in the long term.

9.3 Limitations and future research perspectives

The results of this doctoral research contribute importantly to nutrition and health communication through a better understanding of the role of information in health-related food quality perceptions and food choices. Nevertheless, the choice for a specific research design and methodology has imposed some limitations on this research, which open up opportunities for further research. Limitations and future research perspectives are organised according to the main influencing factors included in the conceptual framework, i.e. related to the person, product, place or environment, and information (Figure 9.1).

Person. A first limitation pertains to participant recruitment, notably the use of convenience sampling methods. As a result, the research findings need to be interpreted within their specific sampling frame, and extrapolation to other populations remains to be further validated. The sample of the consumer survey on the health-related perception of organic compared to conventional vegetables was characterized by an overrepresentation of higher educated adults (Study 3), while the sample in the two studies of the second case study (Study 4 & 5) consisted of mainly undergraduate university students. Future research could repeat presented studies among less educated consumer groups and other age groups such as children and elderly for whom health communication and changing dietary behaviour are assumed to be even more challenging. The higher level of education among the participants of the different studies in this doctoral research made the use of web-based surveys possible which allowed collecting a substantial amount of good quality data in a relatively short time notice against low costs (Schleyer & Forrest, 2000). When considering less educated consumer segments and other age groups, other ways of administering questionnaires as well as the clarity and length of the questionnaire will need to be taken into consideration. However, the ideal questionnaire length may be very different between individuals depending on, for example, their interest and involvement in the research topic, their expectations about the duration of the questionnaire, the number of contacts with the questioner and the use of incentives (Galesic, 2002). Important feedback on these aspects can be obtained from pretesting the questionnaire with a convenience sample of the target population. The larger proportion of female participants in the various studies corresponds with the finding that women show greater interest in diet and health issues but again limits generalization to a more general population (Wardle et al., 2004). By repeating the studies on a larger scale, i.e. with a higher number of participants from different socio-economic backgrounds in a variety of geographical locations, a better identification and targeting of the information needs of different market segments will be possible.

Environment. All presented research is limited to Flanders, Belgium (with the exception of the introductory Chapter 2). However, nutrition and health communication does not stop with regional borders, and its potential role in stimulating informed and healthier food choices is a global matter in today’s society with escalating prevalence of diet-related non-communicable chronic diseases. Chapter 2 indicate that European consumers in general report to attach high importance to the nutritional value of foods in food choices, though the way information about these nutrients should preferably be presented may significantly differ between European countries (Möser et al., 2010). A comparison between European countries regarding the effectiveness of information in terms of health-related quality perceptions and food choices is recommended for future research. Beside the country also the setting of food choice might influence consumers’ response to information (Seymour et al., 2004). As consumer organisations are aiming at a similar nutrition labelling scheme on prepacked foods, foods sold loose and foods sold through catering outlets (BEUC, 2005), a comparison of consumer label preferences across these different settings would be desirable. Moreover, other OH settings than university canteens should be considered such as worksite canteens, schools, hospitals, and restaurants. Within a same setting, the social environment in which consumers make food choices should be taken into consideration in future research since the effectiveness of health communication does not depend solely on individual responsibility but also on the support of the environment (Vaandrager et al., 1993). For young adults, the presence of peers might have a rather negative influence on their food choice behaviour which may explain the lack of effectiveness of nutrition-information interventions.

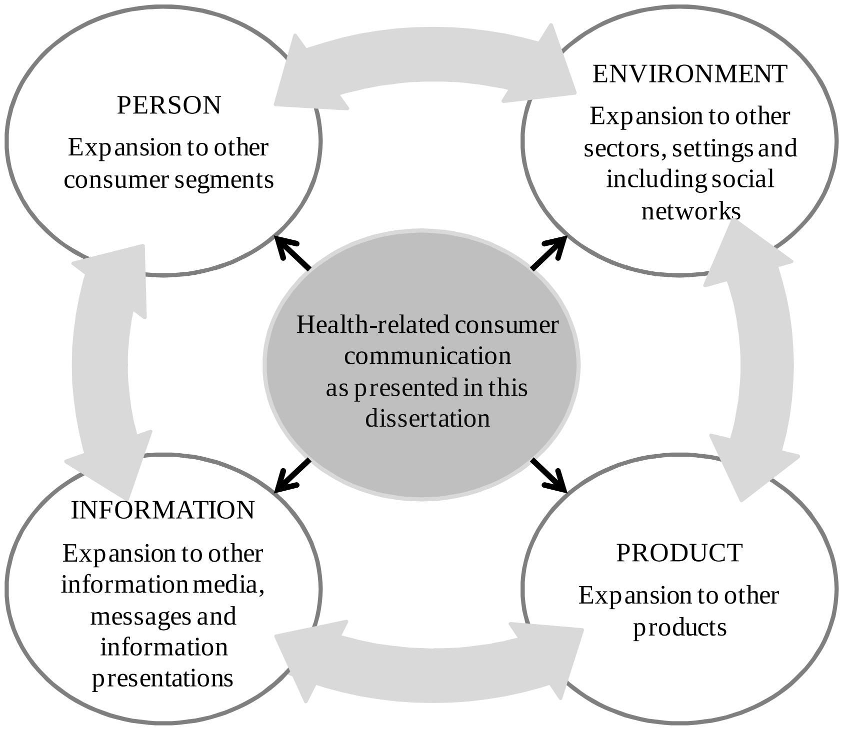


Figure 9.1 Future research perspectives

Product. Different products and product groups varying in perceived healthiness may elicit different consumer responses (Grunert & Wills, 2007). The first case study was limited to vegetables which have a general healthy image. It was found that organic vegetables clearly benefit from favourable health-related perceptions which are even more pronounced among consumers of organic vegetables, resulting in a higher vegetable consumption (Chapters 4 & 5). With respect to the problem of overweight and obesity, an important question to ask is whether the same reasoning goes for less healthy foods. Do consumers eat more of organic foods compared to conventional foods in general? A recent experimental study on cookies and desserts confirmed this assumption (Schuldt & Schwarz, 2010). Future research will need to investigate the effect of the organic claim on actual consumption behaviour but these preliminary insights already indicate the need to educate consumers about the meaning of "organic". A shortcoming of the nutrition-information intervention described in the second case study was the small proportion of canteen meals being offered that complied with the recommendations (or three-star meals). Taking into account that the sensory aspects are major motives for students to choose a meal in university canteens, a similar nutrition-information intervention as presented in this doctoral dissertation with an intrinsically healthier and equally tasteful meal offer could be recommended for future research.

Information. The fact that a higher health-related quality for organic cannot be scientifically substantiated, has an important influence on consumers' perception of organic versus conventional vegetables. To reduce information asymmetry and to enable consumers to make food decisions based on correct and objective information, more well-controlled studies comparing the nutrient and contaminant content of organic and conventional foods (i.e. paired studies) as well as animal and human intervention studies are required. Provided that nutrition communication is trustworthy (i.e. scientifically sound and communicated by a trustworthy information source), it still needs to be used by consumers. The nutrition label implemented in the intervention study (Study 4) appeared not to be used by the majority of the participants primarily because they did neither like nor dislike the label. Further research is recommended to evaluate the effect of the more preferred labelling formats as identified in the choice experiment (Study 5). However, provided that differences between individuals in their motivation to change diet and objective nutrition knowledge moderates the effect of the nutrition-information intervention on food choices, a "one-fit-all" nutrition label is impossible to find. In order to be more responsive to consumer's information needs and interests; more personalized, interactive and persuasive communication of nutrition information in addition to nutrition labelling will need to be considered in future nutrition-information intervention studies. Regarding the content of the information, a better balance between disqualifying and qualifying nutrients/foods in communication strategies is recommended (Chapter 2). Also the way the information is framed has undoubtedly an influence on the effectiveness of the information (Levin et al., 1998). The same accounts for the formulation of the questions in consumer surveys. Future research could investigate how consumers' label preferences differ between alternative framings of nutrition information on labels.

Health-related food quality perceptions are continually evolving in response to changing lifestyles, emerging innovations, demographic evolutions, media agenda, changes in knowledge, and so on. Although the trend for organic for example is still mainly the result of concerns for human health rather than for the environment, environmental and ethical concerns become the longer the more important to consumers when choosing foods (Verbeke et al., 2008b). Consumer expectations for a more efficient use of natural resources to protect the environment makes environmentally sustainable food production and green marketing highly topical consumer issues. Future research will need to take this evolution into account when studying health-related food quality perceptions and their impact on food choices.

To end, a major strength of this doctoral research is undoubtedly the combination of methodologies from two disciplines, food nutrition science and consumer science. Similar interdisciplinary approaches to food choice are highly recommended in future food-health research (Grunert, 2003).

Appendices

Appendix I: References included in meta-analysis (Chapter 3)

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Appendix II: Complete scales and scale items used (Chapters 6, 7, 8)

Construct and items	Scale	Reference	Chapter 6	Chapter 7	Chapter 8
Diet-health awareness	7- point Likert scale	Ragaert et al. (2004)	x		
- I feel to eat healthier now as compared to three years ago*	1 = Totally disagree				
- I feel to have control over my own health*	4 = Neither agree, nor disagree				
- Food plays an important role for keeping me in good health	7 = Totally agree				
- I know which food is healthy for me					
- My health is determined by the food I eat					
Intention to change diet in the next 6 months	7-point interval scale	Ajzen (2002)	x	x	
- I plan to eat more healthy	1 = Very unlikely				
- I expect to eat more healthy	7 = Very likely				
- I desire to eat more healthy					
- I intend to eat more healthy					
- I want to eat more healthy					
Objective nutrition knowledge	True/False	Grunert et al. (2010)	x	x	
Health experts generally recommend that we should try to avoid/eat less/eat about the same/eat more/try to maximize/No idea					
- Fat					
- Polyunsaturated fats					
- Energy					
- Sodium					
- Saturated fat					
- Omega-3 fatty acids					
- Salt					
- Trans fat					
- Sugar					
- Omega-6 fatty acids					
- Fibre					
- Monounsaturated fat					

* item removed after reliability testing

Construct and items	Scale	Reference	Chapter		
			6	7	8
Objective nutrition knowledge *(continued)* *Health experts generally recommend that we should try to avoid/have a little/have some/ have a lot/try to maximize/No idea* - Fruits and vegetables - Starchy foods (bread, rice, pasta, potatoes) - Protein sources (meat, fish, eggs, beans) - Milk and dairy products - Food and drinks that are high in fat - Food and drinks that are high in sugar - Food and drinks that are high in salt	True/False	Grunert et al. (2010)	x	x	
Food choice motives *It is important to me that the meal I choose in a canteen…* Factor 1: Health - … is healthy - … is nutritious - … contains a lot of vitamins and minerals Factor 2: Weight control - … is low in energy - … is low in fat Factor 3: Sensory appeal - … tastes good - … smells nice - … looks nice - … has a pleasant mouth feeling Factor 4: Price - … is not expensive - … is cheap - … is good value for money Factor 5: Familiarity - … is what I usually eat - … is familiar to me Items loading on different factors* - … is low in salt - … is good for my physical and mental health - … is quickly served - … is easily available - … is new on the menu	7-point interval scale 1 = Not at all important 4 = Neutral 7 = Very important	Steptoe et al. (1995)	x		

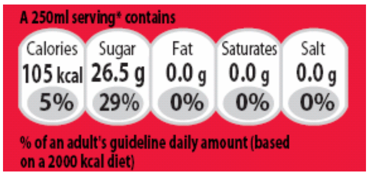
* items removed

Construct and items	Scale	Reference	Chapter		
			6	7	8
Objective understanding of label	True/False			x	x
In your opinion, which of the following definition is correct for the star label? (multiple answers possible)					
- The star label is a tool for making the healthiest meal choice available in the university restaurant					
- The star label is an indication of the best meal options per major meal component (meat, fish, vegetarian)					
- The star label is a guideline to guarantee a recommended daily intake of nutrients					
- The star label is a tool for making healthy menu choices per major meal component (meat, fish, vegetarian)					
- The star label is a guideline to avoid unhealthy meal choices					
What do you understand by above star labels?					
					
- Meals with labels A, B, C, D are equally healthy except that the cause of the lower number of stars is different					
- The meal with label F is the healthiest meal choice					
- The meal with label E is as healthy as the meals with labels A and C					
- The meal with label A is less healthy than the meal with label F					
- The meal with label E is less healthy than the meal with label F					
- The meal with label A contains too much salt					
- The meal with label B contains enough vegetables					
- The meal with label C contains not enough energy					
- The meal with label D contains not enough saturated fat					

Construct and items	Scale	Reference	Chapter		
			6	7	8
Subjective understanding of label - The star label is hard to interpret - The information on the star label is hard to extract - The star label is difficult to understand	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Obayashi et al. (2003)		x	
Liking of label - (Do) like - Attractive - Interesting	7-point interval scale 1 = Totally not 7 = Very (much)	Almanza and Hsieh (1995), Feunekes et al. (2008)		x	
Use of label - To make your meal choice - To choose the healthiest meal - To avoid meals containing too much energy - To avoid meals containing too much saturated fat - To avoid meals containing too much sodium (salt)	7-point interval scale 1 = Never 4 = Sometimes 7 = Always	Fitzgerald et al. (2008)		x	
Subjective knowledge - My friends consider me as an expert in healthy foods - I have a lot of knowledge about how to prepare a healthy meal - I know which food is healthy for me - I have a lot of knowledge about how to evaluate the nutritional value of food	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Pieniak (2008)		x	
Desire for simplicity: inversed scale of Need for Cognition - I would rather do something requiring less thought than something that challenges my thinking abilities - I do not like to have the responsibility of handling a situation that requires a lot of thinking	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Cacioppo et al.(1984)			x

Construct and items	Scale	Reference	Chapter		
			6	7	8
Desire for simplicity: inversed scale of Need for Cognition *(continued)* - I try to anticipate and avoid situations where I will be likely to have to think in depth about something - Thinking is not my idea of fun	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Cacioppo et al. (1984)			x
Desire for full information - If there was a computer in the university restaurant that could supply me with more nutrition information about the meals, I would use it - If there was a code on the meals in the university restaurant that I could use to get more nutrition information through internet, I would use it at home - If there were labels on the meals in the university restaurant that I could use to get more nutrition information, I would use it - I am willing to pay more in the university restaurant for a meal that has more documentation - It is important for me to have direct access to as much nutrition information as possible about the meals in the university restaurant	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Verbeke et al. (2008a)			x
Desire for not being coerced into particular food choices - Nutrition information on a food label that tries to persuade people seems acceptable to me[R] - Nutrition information on a food label that tries to influence people seems acceptable to me[R] - I do not mind nutrition information on a food label that tries to be persuasive without being excessively influencing[R] - I am annoyed by nutrition information on a food label that tries to manage/control people	7- point Likert scale 1 = Totally disagree 4 = Neither agree, nor disagree 7 = Totally agree	Cotte et al. (2005)			x

[R] item reversed for analysis

<table>
<tr><th rowspan="2">Construct and items</th><th rowspan="2">Scale</th><th rowspan="2">Reference</th><th colspan="3">Chapter</th></tr>
<tr><th>6</th><th>7</th><th>8</th></tr>
<tr><td>Objective understanding of GDA label


- The GDA of sugars is 26.5 g
- Around 26.5 servings of a glass of Regular Cola (250 ml) would contain my total GDA for the day
- A glass of Regular Cola (250ml) contains 26.5 g of sugars
- 26.5% of a glass of Regular Cola (250ml) is sugar
- A glass of Regular Cola (250ml) contains 26.5% of my GDA of sugar</td><td>True/false</td><td>Grunert et al. (2010)</td><td></td><td></td><td>x</td></tr>
<tr><td>Motivation to process nutrition information about canteen meals
- I would like to receive nutrition information about the meals in the university restaurant
- If there were labels on the meals in the university restaurant that I could use to get more nutrition information, I would pay attention to it
- It is important to me that nutrition information is available about the meals in the university restaurant
- If there were labels on the meals in the university restaurant that I could use to get more nutrition information, I would use it</td><td>7- point Likert scale
1 = Totally disagree
4 = Neither agree, nor disagree
7 = Totally agree</td><td>Keller et al. (1997), Moorman (1990)</td><td></td><td></td><td>x</td></tr>
</table>

Summary

Due to consumers' increased health concerns and awareness of the relationship between diet and health, health-related food quality aspects have become of increasing importance in their food choices. From a consumer perspective, the health-related quality of a food refers to the nutritional value and safety of foods. The rising prevalence of diet-related non-communicable chronic diseases suggests that many consumers experience difficulties in making healthier food choices. A major barrier is the fact that consumers may not perceive the healthiness of foods either before nor after consumption, but they need to infer it from various information (or quality cues). To improve nutrition and health communication and as such hopefully consumers' food choices, thorough insights are necessary in the role of information in how consumers perceive the health-related quality of a food and make food choices. In this regard, the overall objective of this doctoral dissertation was to evaluate whether extrinsic quality cues have scientifically desired effects on consumers' health-related food quality perceptions and food choices. This doctoral research included two case studies: one covering organic production as a quality cue for vegetables, the other nutrition information on canteen meals. Both primary and secondary data were collected in five independent studies conducted in Flanders, Belgium, among (young) adults in the period of 2006-2010. The main findings for the four research objectives of this research are presented:

The first objective consisted of exploring the gap between scientific evidence and consumers' perception regarding the nutritional value and safety of organic versus conventional vegetables. The profound meta-analysis revealed that organic vegetables are not healthier than the conventional alternative. Inconsistent findings with respect to differences in nutrient content were found between the organic and conventional food. The generally higher contents of pesticide residues and nitrates in the conventional food remained far below the statutory maximum amounts. Consumers, however, generally perceived organic vegetables as containing less contaminants and more nutrients, and thus being healthier than conventional vegetables. The gap between facts and consumer perceptions was the largest for the health character, nutritional value and microbial safety, especially among older consumers with children and heavy users of organic vegetables.

The second objective pertained to the influence of consumers' health-related perception of organic on the consumption of vegetables. Consumers' more favourable perception of the health-related quality of organic compared to conventional vegetables was associated with a higher vegetable consumption among consumers of organic vegetables. A higher vegetable consumption means a higher intake of nutrients as well as contaminants. As such, the consumption pattern was found to be more important than differences in nutrient and contaminant content between organic and conventional vegetables.

The third objective was to evaluate the effectiveness of posting point-of-purchase nutrition information in university canteens in improving meal choices and nutrient intakes. In general, the intervention did not improve students' canteen meal choice and nutrient intake. The nutritional value of the meal choices were far from recommended. The healthiest choices were made by students with higher objective nutrition knowledge, stronger health and weight-control motives, and a higher openness to change meal choices at baseline. Those liking the nutrition label more, declared to use the label more often and were more likely to positively change their attitude towards healthy meals. Motivation to change diet and sufficient objective nutrition knowledge were required for effective label use and to maintain or improve the energy intake from meals. Future nutrition-information interventions in canteens may be more effective with a healthier meal supply and a label that is generally liked by the target population in combination with nutrition education.

As a fourth objective, consumer preferences for alternative formats of nutrition information in university canteens were identified and explained. Students valued the presence of nutrition labels on canteen meals and showed a preference for more detailed information. Provision of too detailed and too simplistic nutrition information resulted in information overload and information insufficiency, respectively. Ability and motivation to process information as well as socio-demographics contributed to the explanation of the observed differences in label preferences. A nutrition label providing the energy content relatively to its guideline daily amount together with an overall appreciation of the nutritional quality of the meal by means of familiar interpretational aids such as stars and colour codes is proposed for future use in university canteens.

In conclusion, the studied quality cues (among many other) are not very successful in correctly informing consumers about the health-related quality of foods and in improving their food choices. From a scientific perspective, the organic claim for vegetables seems to fail due to a lack of underlying scientific evidence. Where science is more undecided, consumer perceptions are more often based on stereotypes, image transfer and emotion instead of factual knowledge. As long as there is no scientific evidence about the added value of organic vegetable consumption for health, an evaluation and approval process of organic claims similar to that of nutrition and health claims is suggested to avoid misleading consumer communication. Even when consumer communication is science based like in the second case study, informed food choices cannot be taken for granted. Person-, information- and product-related factors have shown to influence the effectiveness of the nutrition-information intervention in university canteens. The implications for nutrition and health communication are that the audience needs to be better understood, segmented, identified and targeted. An improved communication strategy would be to use both a generic nutrition label and specifically tailored information to consumers. Also other strategies than consumer communication such as environmental strategies addressing the availability of healthy and tasteful food products, should be considered if consumers are to be stimulated to make better informed and healthier food choices in the future.

Samenvatting

Door een toegenomen bewustwording van de relatie tussen voeding en gezondheid vinden consumenten gezondheidsgerelateerde voedselkwaliteitsaspecten alsmaar belangrijker bij het maken van voedingskeuzes. Consumenten beschouwen de voedingswaarde en veiligheid van voedingsmiddelen als de voornaamste gezondheidsgerelateerde kwaliteitsaspecten. De steeds toenemende prevalentie van voedingsgerelateerde chronische ziekten wijst erop dat een belangrijke groep van consumenten moeilijkheden ondervindt bij het maken van gezondere voedingskeuzes. Het belangrijkste probleem hierbij is dat consumenten de gezondheidswaarde van een voedingsmiddel voor noch na consumptie kunnen ervaren. Zij dienen zich hiervoor te baseren op beschikbare informatie (of kwaliteitsindicatoren). Kennis van de rol van informatie in de manier waarop consumenten de gezondheidsgerelateerde kwaliteit van een voedingsmiddel ervaren is noodzakelijk om communicatie over voeding en gezondheid en bijgevolg de keuze van consumenten te verbeteren. De algemene doelstelling van dit doctoraat was na te gaan of kwaliteitsindicatoren het gewenste effect hebben op gezondheidsgerelateerde kwaliteitspercepties en keuzes van consumenten inzake voeding. Dit doctoraatsonderzoek bestond uit twee gevalsstudies: de eerste betrof de biologische productie als kwaliteitsindicator voor groenten en de tweede nutritionele informatie voor kantinemaaltijden. Zowel primaire als secundaire gegevens werden verzameld in het kader van vijf onafhankelijke studies in Vlaanderen, België, bij (jong) volwassenen in de periode 2006-2010. De hoofdbevindingen bij elk van de vier onderzoeksdoelstellingen worden hieronder samengevat.

Als eerste doelstelling werd de kloof tussen de wetenschappelijke feiten en de perceptie van de consument inzake de voedingswaarde en veiligheid van biologische versus gangbare groenten onderzocht. De uitgebreide meta-analyse toonde aan dat biologische groenten niet gezonder zijn dan de gangbare variant. Op basis van de beschikbare wetenschappelijke literatuur kon niet eenduidig worden besloten dat bio beter scoort. Afhankelijk van het beschouwde nutriënt en de beschouwde groente scoorde bio soms beter en soms slechter dan het gangbare product. De algemeen hogere gehalten aan pesticide residu’s en nitraten in de gangbare groente bleef onder de maximum toegelaten hoeveelheid. De consumenten percipieerden biologische groenten als zijnde armer in contaminanten en rijker aan nutriënten en bijgevolg gezonder dan gangbare groenten. De kloof tussen wetenschappelijke feiten en consumentenpercepties was het meest uitgesproken voor de gezondheidswaarde, voedingswaarde en de microbiologische kwaliteit en dit vooral bij oudere consumenten met kinderen en *heavy users* van biologische groenten.

De tweede doelstelling bestond erin na te gaan wat de invloed is van de gezondheidsgerelateerde perceptie van bio op de consumptie van biologische groenten. De positievere perceptie van de gezondheidsgerelateerde kwaliteit van biologische groenten in vergelijking met gangbare groenten resulteerde in een hogere groenteconsumptie bij consumenten van biologische groenten. Een hogere groenteconsumptie betekent een hogere inname van nutriënten en contaminanten. Bijgevolg werd het consumptiepatroon belangrijker bevonden dan mogelijke verschillen in het gehalte aan nutriënten en contaminanten tussen biologische en gangbare groenten.

Als derde doelstelling werd vooropgesteld om de doeltreffendheid te evalueren van nutritionele informatie in universiteitskantines met als doel de maaltijdkeuze en inname van nutriënten te verbeteren. Over het algemeen bleek de interventie geen effect te hebben op de maaltijdkeuze van studenten en de inname van nutriënten. De voedingswaarde van de maaltijdkeuze kwam niet overeen met de aanbeveling. De gezondste keuzes werden gemaakt door studenten met een hogere objectieve kennis over voeding en door studenten die meer begaan waren met hun gezondheid en gewicht, en meer openstonden voor een verandering van maaltijdkeuze. Diegenen die het voedingslabel aantrekkelijker vonden, gaven aan dat ze het label vaker gebruikten en waren meer geneigd om hun houding ten aanzien van gezonde maaltijden in positieve zin te veranderen. Motivatie om het voedingspatroon te veranderen en voldoende objectieve kennis over voeding waren vereist opdat het label effectief werd gebruikt om de energie-inname te verminderen of te behouden in het geval deze goed was. Toekomstige interventies die gebruik maken van nutritionele informatie worden verwacht doeltreffender te zijn indien een gezonder maaltijdaanbod voorhanden is, een label gebruikt wordt dat algemeen aantrekkelijk wordt bevonden door het doelpubliek en gecombineerd wordt met voedingsvoorlichting.

De vierde doelstelling bestond erin de voorkeur van consumenten voor alternatieve weergave van nutritionele informatie te identificeren en te verklaren. Studenten apprecieerden de beschikbaarheid van nutritionele informatie voor kantinemaaltijden en hadden een voorkeur voor meer gedetailleerde informatie. Het voorzien van te gedetailleerde nutritionele informatie alsook te vereenvoudigde informatie resulteerde in indicaties van, respectievelijk, verzadiging van informatie en een tekort aan informatie. Het vermogen en de motivatie om informatie te verwerken alsook socio-demografische kenmerken droegen bij tot de verklaring van verschillen in voorkeuren voor de voorstelling van nutritionele informatie. Er wordt aangeraden aan universiteitskantines om in de toekomst gebruik te maken van een voedingslabel met informatie over de energiewaarde ten opzichte van de dagelijkse voedingsrichtlijn en een algemene appreciatie van de nutritionele kwaliteit van de maaltijd door middel van eenvoudig interpreteerbare sterren en kleurencodes.

Ten slotte, de kwaliteitsindicatoren die in dit doctoraatsonderzoek werden bestudeerd, bleken niet erg succesvol te zijn bij het correct informeren van consumenten over de gezondheidsgerelateerde kwaliteit van voedingsmiddelen en in het verbeteren van de voedingskeuzes. Vanuit een wetenschappelijk standpunt, blijkt de biologische claim voor groenten te falen door een gebrek aan onderliggend wetenschappelijk bewijs en consensus. Consumentenpercepties zijn vaker gebaseerd op stereotypen, imago en emotie in plaats van feitelijke kennis wanneer onvoldoende wetenschappelijk bewijs voorhanden is. Zolang er onvoldoende bewijskracht is omtrent de meerwaarde van bio voor de gezondheid, wordt een evaluatie- en goedkeuringsprocedure aangeraden voor biologische claims gelijkaardig aan deze van voedings- en gezondheidsclaims. Ook in het geval de communicatie naar consumenten toe wetenschappelijk onderbouwd is zoals in de tweede gevalsstudie, zijn geïnformeerde voedingskeuzes geen evidentie. Persoons-, informatie- en productgebonden factoren beïnvloedden de doeltreffendheid van de interventiestudie in de universiteitskantines. Belangrijke implicaties zijn dat de communicatie over voeding en gezondheid meer gericht moet zijn naar de noden van het doelpubliek die op haar beurt beter dient begrepen, gesegmenteerd en geïdentificeerd te worden. Een betere communicatiestrategie zou zijn om een generiek voedingslabel te gebruiken gecombineerd met informatie op maat voor consumenten. Ook andere strategieën dan het gebruik van informatie dienen in de toekomst in rekening gebracht te worden opdat consumenten verder gestimuleerd worden om beter geïnformeerde en gezondere voedingskeuzes te maken. Omgevingsinterventies die zich toeleggen op het aanbod aan gezondere en smaakvolle voedingsmiddelen zijn hiervan een voorbeeld.

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Publications

Articles in peer-reviewed international journals

Hoefkens, C., Sioen, I., De Henauw, S., Vandekinderen, I., Baert, K., De Meulenaer, B., Devlieghere, F., & Van Camp, J. (2009). Development of vegetable composition databases based on available data for probabilistic nutrient and contaminant intake assessments. *Food Chemistry, 113*(3), 799-803.

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Articles in national journals (A3)

Hoefkens, C., Verbeke, W., & Van Camp, J. (2011). Consumer perception and behaviour related to food labelling. *Communications in Agricultural and Applied Biological Sciences*, *76*(1), 89-92.

Attended international conferences and seminars with oral or poster presentation

Hoefkens, C., Van Camp, J., Sioen, I., Vandekinderen, I., Baert, K., De Meulenaer, B., Devlieghere, F., & De Henauw, S. (2007). Development of food composition databases based on available data for probabilistic nutrient and contaminant intake assessments. Poster presentation on 2nd International EuroFIR Congress, Granada, Spain, September 26-27, 2007.

Aertsens, J., Mondelaers, K., Van Huylenbroeck, G., & Hoefkens, C. (2007). Surplus value of organic food and farming. Oral presentation on QLIF Training & Exchange workshop Measuring food quality: concepts, methods and challenges, Driebergen, The Netherlands, February 12-14, 2007.

Hoefkens, C., Sioen, I., De Henauw, S., Vandekinderen, I., Baert, K., De Meulenaer, B., Devlieghere, F., & Van Camp, J. (2007). Development of vegetable composition databases based on available data for probabilistic nutrient and contaminant intake assessments. Poster presentation on The International Fruit and Vegetable Summit, Paris, France, May 27-30, 2008. (presented by John Van Camp)

Hoefkens, C., Verbeke, W., & Van Camp, J. (2008). Consumers' perception and preferred format of nutritional profile labelling: exploratory insights from Flanders. Poster presentation on 3rd EuroFIR Network Meeting and Associated Workshops, Prague, Czech Republic, September 15-19, 2008.

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Möser, A., Hoefkens, C., Van Camp, J., & Verbeke, W. (2009). Nutrient profile labelling: consumers' perceptions in Germany and Belgium. Oral presentation on 113th EAAE Seminar "A resilient European food industry and food chain in a challenging world", Crete, Greece, September 3-6, 2009. (presented by Anke Möser)

Hoefkens, C., Verbeke, W., & Van Camp J. (2010). Effectiveness of a university-based nutrition labelling program on the nutrient intake from canteen meals. Poster presentation on the II World Congress of Public Health Nutrition and I Latin American Congress of Community Nutrition, Porto, Spain, September 23-25, 2010. Poster has been awarded the Excellence in Research award by DSM in recognition of undertaking research that has scientific, policy and/or programmatic relevance.

Hoefkens, C., Verbeke, W., & Van Camp J. (2010). Differences in European consumers' perceived importance of nutrients. Poster presentation on the II World Congress of Public Health Nutrition and I Latin American Congress of Community Nutrition, Porto, Spain, September 23-25, 2010.

Hoefkens, C., Verbeke, W., & Van Camp J. (2011). Nutrition labelling intervention in university canteens: Effects on meal choice and nutrient intake? Oral presentation on 9th International MAPP Workshop on Consumer Behaviour and Food Marketing, Middelfart, Denmark, May 10-11, 2011.

Attended national seminars, conferences or events

Van Camp, J., & Hoefkens, C. (2007). De meerwaarde van bio op gebied van kwaliteit en gezondheid, wetenschappelijk onderzoek naar feiten en perceptie. Voedingswaarde en voedselveiligheid van groenten, bio en gangbaar vergeleken. Oral presentation on Themanamiddag Milieu en Gezondheid, Antwerp, Belgium, May 15, 2007. (presented by John Van Camp)

Hoefkens, C., Verbeke, W., & Van Camp, J. (2009). Consumers' response to nutrition labelling in a catering environment. Poster presentation on the 15th Symposium on Applied Biological Sciences, Leuven, Belgium, November 6, 2009.

Hoefkens, C., Lachat, C., Van Camp, J., Verbeke, W., & Kolsteren, P. (2010). A toolbox to improve diets of canteen customers. Poster presentation on Exchange conference: Open innovation for feed, food & health, where industry and academia meet, Ghent, Belgium September 28, 2010.

Hoefkens, C., Verbeke, W., & Van Camp, J. (2010). Consumer perception and behaviour related to food labelling. Oral presentation on the 16th Symposium on Applied Biological Sciences, Ghent, Belgium, December 20, 2010.

Supervision of master students

Karen Van Den Bossche (2006-2007). Risico-baten analyse van biologische groenten versus conventionele groenten. Promoters: Prof. dr. ir. J. Van Camp & Prof. dr. S. De Henauw. Thesis to obtain the degree of Bio-Engineer, master Agriculture.

Evy Roets (2008-2009). Identificatie van consumentensegmenten op basis van het nutriëntenprofiel van de maaltijdkeuze in een bedrijfsrestaurant. Promoters: Prof. dr. ir. W. Verbeke & Prof. dr. ir. J. Van Camp. Thesis to obtain the degree of Bio-Engineer, master Chemistry.

Wim Van Hauwaert (2008-2009). Relation between dietary behaviour and body mass index of university canteen customers. Promoters: Prof. dr. ir. W. Verbeke & Prof. dr. ir. J. Van Camp. Thesis to obtain the degree of Master of Human Nutrition and Rural Development.

Vero Lalaina Andriambelosoa (2009-2010). The effect of food labelling in two university canteens on determinants of dietary behaviour, and energy and nutrient intake from canteen meals. Promoters: Prof. dr. ir. W. Verbeke & Prof. dr. ir. J. Van Camp. Thesis to obtain the degree of Master of Human Nutrition and Rural Development.

Eline Hebbelinck and Daphly Troch (2009-2010). Nutriënteninname bij studenten: een onderzoek in twee studentenrestaurants van de Universiteit Gent. Promoters: Prof. dr. ir. W. Verbeke & Prof. dr. ir. J. Van Camp. Thesis to obtain the degree of Voedings- en Dieetkunde (Hogeschool Gent).