

**SENSORY AND NON-SENSORY FACTORS BEHIND THE  
LIKING AND CHOICE OF HEALTHY FOOD PRODUCTS**

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## **ABSTRACT**

A healthy and balanced diet can reduce health problems, such as overweight and metabolic syndrome. In general, people have a considerably good knowledge of what constitutes a healthy diet and how they could achieve it with their food choices. Besides, people argue that health is among their top five food choice motives. Nevertheless, the prevalence of overweight is increasing and other food choice motives, such as taste, seem to conflict with the health. Liking for food does not necessarily determine acceptance alone, thus several non-sensory factors, such as brand, country of origin and nutrition claim, can also influence. Moreover, consumers are individuals in how they prioritize sensory and non-sensory factors of foods, but e.g. increasing age, female gender and health concern have been connected to a more health-oriented dietary behaviour. To sum up, identifying different factors that can increase the liking and consumption of healthy food is essential in order to develop more attractive healthful food products.

Adding vitamins, minerals, fibre or other ingredients to a food product can be used to enrich the nutritional quality of the products. However, this may be difficult in practice as regards the sensory quality and pleasantness of the foods. Generally, consumers are not willing to compromise on taste in food. On the other hand, consumers are very heterogeneous in their likings, and their personal values and attitudes may interact with preferences for specific sensory characteristics. The aims of this study were to investigate the effects of intrinsic product characteristics on sensory properties and hedonic responses; to determine the impact of few non-sensory factors; and to examine the interaction between sensory and non-sensory factors with consumers' demographics, values and attitudes in liking of healthy model foods.

The results showed that product composition influenced sensory quality and had an effect on hedonic responses. Adding flaxseed to bakery products showed a significant improvement in the nutritional quality without negative effects on sensory properties. On the other hand, the fortification of wellness beverages with vitamins and minerals may impart off-flavours. In general, sweetness of yoghurts, freshness of wellness beverages and low intensity of rye bread flavour appealed to consumers. Information about the domestic

origin of yoghurts and claiming a specific function for wellness beverages enhanced liking. However, consumers who were more concerned about their health and considered natural content as an important food choice motive, rated sourer and less sweet yoghurts and wellness beverages as more pleasant. In addition, interest in health increased the consumption of rye breads and other whole grain breads among adolescents. The results showed that the optimal product quality in terms of intrinsic and extrinsic factors differs between individual consumers, and personal values and food choice motives can be connected to preferences for specific sensory characteristics of foods. This indicates that each food product needs to be considered in relation to its specific market niche, and to which segment of consumer will respond most positively to its characteristics.

## LIST OF ORIGINAL PUBLICATIONS

- I Pohjanheimo, T., Hakala, M., Tahvonen, R., Salminen, S., and Kallio, H. (2006). Flaxseed in breadmaking: Effects on sensory quality, aging, and composition of bakery products. *Journal of Food Science*, 71, S343-348.
- II Pohjanheimo, T., and Sandell, M. (2009). Headspace volatiles contributing to flavour and consumer liking of wellness beverages. *Food Chemistry*, 115, 843-851.
- III Pohjanheimo, T., and Sandell, M. (2009). Explaining the liking for drinking yogurt: the role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, 19, 459-466.
- IV Pohjanheimo, T., Paasovaara, R., Luomala, H., and Sandell, M. Exploring the food choice motives and rye bread liking of consumers embracing hedonistic and traditional values. *Appetite*, *In Press*.
- V Pohjanheimo, T., Luomala, H., and Tahvonen, R. Adolescents' attitudes toward wholegrain bread and health. *Submitted*.

# 1 INTRODUCTION

An increasing interest in healthy food has multiplied the number of new products on the market. Manufacturers always have the target of making a successful product launch and having a long product life. However, failure rates are high though manufacturers have worked hard in order to develop pleasant food product for the consumers. Predicting consumers' food choices successfully involves studies combining sensory food science with the product related non-sensory factors.

The field of sensory food science is a rather young research area, but it has grown rapidly in the second half of the 20<sup>th</sup> century. Originally, sensory analysis has focused on measuring human responses to foods while the potentially biasing effects of brand identity and other non-sensory factors influencing consumer perception are minimized in order to isolate the opinion based on sensory properties only (Lawless and Heymann, 1999). There, the sensory science has developed separately from the consumer behaviour, i.e. marketing research, which examines concepts about the whole food product. However, marketing research has evolved in marketing, where knowledge about the sensory and nutritional aspects of the products has been limited. This has led to the situation where the product development and marketing departments do not co-operate, a lot of resources are untapped and the flop rates of new products continue to be high (Köster, 2009). Many researchers call for more interdisciplinary research to examine the relationships between sensory and non-sensory factors (e.g. Enneking et al., 2007; Jaeger, 2006). After all, over the last two decades sensory science has been extended in the direction of consumer insight and new methods have been developed to investigate the relationships among product-related sensory and non-sensory factors and consumer-related factors.

The general aim of this thesis was to gather together the widely distributed research results from both sensory food science and consumer behaviour disciplines related to the liking and food choice behaviour, with the primarily focus on food healthfulness. The focus of the literature review was on consumer's food choices and preferences: why do people choose the way they do; and how different sensory and non-sensory factors, and consumer-

related factors influence the food choice and liking? This thesis combines general theories as well as several individual studies of sensory food science and consumer behaviour research to demonstrate the complexity behind the food perception. The specific factors considered here were chosen either because they have been frequently addressed in the food choice literature or because they were investigated in the experimental part of this thesis. However, there are also other factors, e.g. the role of habit or emotions in food choice, which have a verifiable influence on food choice (Honkanen et al., 2005; Macht et al., 2002). By including the health aspect in our framework, we focused on the different incentives which can increase the liking, choice and consumption of healthier food products. The aim of the experimental part of this thesis was to investigate the relationships among product composition, sensory characteristics, non-sensory factors and consumer differences and their influence on the liking of different food products that can be considered as healthy.

## **2 REVIEW OF THE LITERATURE**

### **2.1 The functions of food**

Our food has several functions. First of all, people have a physiological need for food, i.e. alleviating a person's hunger, which contains functions like growth, maintenance, reproduction, and activity (Sijtsema et al., 2002). At the beginning of the 20<sup>th</sup> century this function was the most decisive element of food consumption. However, diets and lifestyles of the population have changed due to industrialization, economic development and market globalization and have had a significant influence on the nutritional status of populations. Nowadays in many countries, an increasing proportion of food consumption appears to be driven by pleasure, not the need for calories, suggest Lowe and Butryn (2007). That is, people also attach psychological and social needs to foods, which can be divided furthermore into several functions, such as the gastronomic function (i.e. hedonistic part of eating); the communication function (i.e. eating the meal together); the status function (i.e. people can discern themselves from others); and the religious function (i.e. certain products have a symbolic meanings, e.g. Jewish people do not eat pork) (Sijtsema et al., 2002). While standards of living have improved and food availability has expanded, there have also been negative consequences such as inappropriate dietary patterns and increase in diet-related chronic diseases (WHO, 2003). Food and its consumption is a broad research field and is studied by food scientists, consumer researchers, nutritionists, agricultural economists, psychologists, sociologists and anthropologists among several others, where each discipline has its own primary concerns (Sijtsema et al., 2002; Wilson, 2002).

### **2.2 Food perception**

A person shopping in a grocery shop or enjoying his meal perceives a lot of sensations related to food. In the grocery store, the sensations are mostly related to a variety of visual information of product packages, advertisements and nutrition information, while in the eating situation different odours and flavours are experienced. These processes are termed perception, where the information from our sensory receptors (e.g. eyes, nose, mouth, ears,

and fingers) is selected, organized and interpreted (Solomon et al., 2006). Perception is based on sensorial observations of an individual (perceptor) and product characteristics (stimuli) (Sijtsema et al. 2002). It can be described as 'how we see the world around us'.

People are constantly bombarded with variety stimuli every minute. We can perceive different sensations related to food as the sensory receptors' response to the stimuli inputs of a product while we buy, prepare, and consume food. The sensory world is made up of an almost infinite number of discrete sensations that are constantly and subtly changing. Therefore, consumers subconsciously exclude a large amount of stimuli and will perceive only a small fraction of the stimuli to which they are exposed. Two individuals may be exposed to the same stimuli under the same conditions, but how each person recognises, selects, organises and interprets these stimuli is a highly individual process based on each person's own characteristics, motives and expectations at the time (Schiffman et al., 2008). Is a person looking forward to a healthy meal or just a snack, and furthermore, how should the product look, taste and cost? The large variation of different stimuli related to the products together with divergences between consumers has led to the fact that the food industry constantly has to find new answers how to stand out from the others, and how to attract and persuade the consumer into selection of their product.

### **2.2.1 Measuring food perception**

A discipline that deals with the human sensory perception of foods, beverages and their components is called sensory food science (Tuorila and Monteleone, 2009). Sensory food science uses sensory evaluation as its analytical method, which accurately measures human responses to foods. Sensory evaluation is defined as a scientific method used to evoke, measure, analyze, and interpret those responses to products as perceived through our sensory receptors. The basic attempt in sensory evaluation is to isolate the sensory properties of food and minimize the potentially biasing effects of product packages, brand identity and other information influencing consumer perception (Lawless and Heymann, 1999).

Sensory analysis can be used, for example, to reveal perceived changes to human beings that occur due to product modifications. Depending upon the research question, there are different research methods for different tasks. Descriptive sensory methods are used to quantify the perceived differences among product variants and involve subjects screened for sensory acuity and trained for evaluation. Hedonic tests attempt to quantify the degree of liking (a.k.a. hedonic response) of a product and involve untrained subjects screened for product usage. (Lawless and Heymann, 1999; Tuorila and Monteleone, 2009) Sensory analysis should be an integral part of product development in the food industry since only human sensory data can provide the information how consumers are likely to perceive and react to food products in real life. In addition, certain sensory analysis can be completed and compared to physical-chemical measurements in specific circumstances (e.g. the sample handling should be identical in both measurements). However, if sensory analysis is replaced by physical or chemical measurements, careful studies concerning the equivalence of the results will have to be carried out.

The field of consumer behaviour, rooted in the marketing concept, examines different aspects of the product concept and the selling concept on consumers' purchase behaviour (Schiffman et al., 2008). Consumer research methods in the food sector are interested in how the non-sensory factors, such as brand and package of the product, price, promotion (e.g. advertising), and place, where the product can be purchased, influence consumer behaviour and food choice. Food acceptance depends both on sensory and non-sensory factors. Today, combining non-sensory factors with sensory food science receives great interest both in academic research as well as in the food industry.

### **2.3 Food choice**

Understanding consumers' motivations in the food choice situation are necessary in order to guide the nutritional status of population into a healthier direction. Due to the large variety of food products on the market, consumers make a multitude of food choices on a daily basis. However, consumers' food choices are not easy to predict. An individual does not necessarily behave in the similar manner twice, even if the situation and different sensory stimuli stays similar.

Figure 1 represents an overview of the consumers' decision-making process drawing together different models from Brunsø et al., 2002, Furst et al. (1996), Connors et al. (2001), Solomon et al. (2006) and Steenkamp (1990). First, in order to conduct a food choice, the consumer needs or wants a food item (Fig 1: Box 1). After the preliminary decision to purchase a food item has been made, the consumer can evaluate different alternatives (Fig 1: Box 3). Many times inside the same product category the food choice process is made automatically; a consumer does not spend time to decide what milk he will purchase. At other times, however, rarely with food products, a person may spend a lot of time thinking about a purchase and evaluating different alternatives. Availability can be seen as the primary determinant of food choice (Mela, 1999). If a certain product is not available, it will not be eaten and if there is no alternative available, it will be eaten. However, not to make the prediction of consumers' food choice too simple, consumers regularly purchase multiple products from the same product category, while purchase assumptions are typically restricted for single-unit purchases. For example, Dubé (2004) showed that only 39% of the trips to purchase carbonated soft drinks resulted in the purchase of a single unit of the same brand. Faced with several alternatives, the food choice process is made more complex in many ways.

Different factors influencing food choice behaviour can be roughly divided into three main groups (Shepherd, 1989). First, there is the food product itself, together with the sensory and non-sensory characteristics, which have showed a variety impact on choice behaviour (see for example, Bower et al., 2003; Di Monaco et al., 2003; Guinard et al., 2001; Roosen et al., 2007). Second, there is personal factors of the consumer, such as demographics (Hearty et al., 2007; Wadolowska et al., 2008), motives (Steptoe and Wardle, 1999), prior expectations (Deliza and MacFie, 1996; Erdem, 1996), body image, physiological restrictions (Bisogni et al., 2002) and weight status e.g. obesity (Berg et al., 2009; Carnell and Wardle, 2008). Third, there is the socio-economic environment and context where the food choice and consumption will take place (King et al., 2004; Mela, 1999).

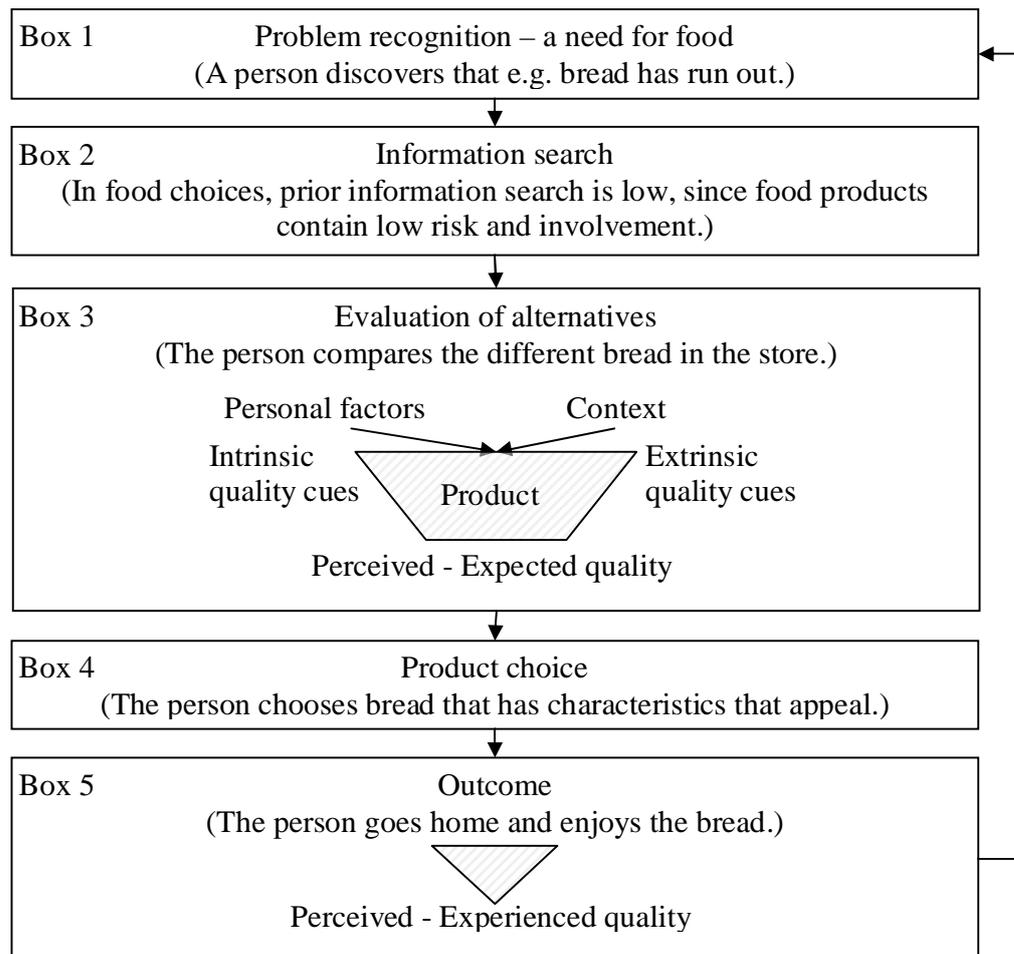


Figure 1. Stages in consumer decision-making. Constructed from Brunso et al., 2002, Connors et al. (2001), Furst et al. (1996), Solomon et al. (2006) and Steenkamp (1990).

### 2.3.1 Food choice motives

Faced with a food choice situation, a person uses a set of motives, which are relevant to him in the context (Connors et al., 2001; Fig. 1: Box 3). Several studies have shown that taste, price and healthiness are among the top most important influences on consumers' food choice. 14 331 European consumers rated "quality/freshness", "price", "taste", "trying to eat healthy" and "what my family want to eat" as the top five with some variation in the order of importance between the countries (Lappalainen et al., 1998). Kearney et al. (2000) obtained motives such as "quality", "taste", "healthy" and "other people's preferences" in this order as the most important in Ireland (n = 1009). In agreement with previous research, Americans rated taste, cost, nutrition/health and convenience as the primary food choice motives according to Glanz et al. (1998) (n =

2967) and Connors et al. (2001) (n = 86). Moreover, Steptoe et al. (1995) developed a multidimensional measure to examine motives related to food choice called the Food Choice Questionnaire (FCQ). Data collected using the FCQ in Europe and in New Zealand show similar food choice motives as in the studies referred to earlier, and classify sensory characteristics, health, price and convenience as the most important food choice motives for the consumers (Eertmans et al., 2005; Lindeman & Väänänen, 2000; Prescott et al., 2002; Steptoe et al., 1995).

However, all food choice motives are not equally important for all consumers (Connors et al., 2001) and there are several personal factors that can have an influence as mentioned above. For example, people watching their figure may attach more weight to the fat content of a food. People categorize foods with multiple attributes so that a particular food can be expensive but also tasty and healthy. Many times optimizing all motives at the same time in the same food may be difficult and, for example, tasty, favourite food does not necessarily meet the health motivation. These conflicts make it necessary to prioritize primary motivations and a person needs to find a food item that fits two or more preferred categories. The outcome of the prioritization can vary according to the situation and the product (Connors et al., 2001; Steenkamp, 1986). For example, the fat content may be a quality attribute for a meat product, but not relevant for fruits (Ophuis and van Trijp, 1995).

### **2.3.2 Quality perception process**

Consumers argue that food quality is one of the most important food choice motives for them (Kearney et al., 2000; Lappalainen et al., 1998). But actually, food quality is a multifaceted and a very subjective concept on the whole, and all the food choice motives rated by the consumers are somehow related to food quality. When asking consumers what they regard as food products of good quality, their answers mainly have four major dimensions: taste (and other sensory characteristics), health, convenience, and the production process according to Brunsø et al. (2002). Generally, the term “quality” lacks a clear definition. It is accepted that quality has both an objective and subjective dimension; meaning that a part of overall quality can be measured. Bremner (2000) defines that the

overall concept of quality that in itself is not measurable is closely related to product quality parameters, which can be determined by analytical standard methods. Quality for a consumer is different than, for example, for a food company producing the food. For example, Olsen et al. (2008) found that the product development managers' main focus on quality was food safety and compliance with specifications, whereas Moskowitz (1995) suggested that for a consumer, the quality concept correlates strongly with the overall liking of a product. It seems that regardless of the research field (e.g. food, psychological or marketing research), researchers agree that a quality is a complex term (Grunert, 1995; Lawless, 1995; Moskowitz, 1995; Ophuis and van Trijp, 1995; Steenkamp, 1990).

The concept of perceived quality should be used when considering food quality from the consumers' point of view. It has been suggested that perceived quality is the main determinant of consumer food choice (Olsen et al., 2008). Perceived quality is the result of the perception process, but the concept has not yet achieved a common accepted definition. Steenkamp (1990) defined perceived quality as based on relevant characteristics of the product within the context of personal and situational variables (Fig 1: Box 3). This indicates that there is not necessarily "one best quality" for all consumers (Lawless, 1995; Steenkamp, 1986).

The Total Food Quality Model is one model developed to explain quality perception process from the consumers' point of view (Grunert, 1997). The model assumes that expected quality is based on a number of perceived quality cues, which are commonly distinguished between intrinsic and extrinsic quality cues (Olson and Jacoby, 1972; Fig. 1: Box 3; Table 1). In addition, experience and credence quality attributes have a role in quality perception (Ophuis and van Trijp, 1995; Steenkamp, 1990; Table 1).

Table 1. Quality cues and quality attributes for foods according to Ophuis and van Trijp (1995).

	Variables
Intrinsic quality cues	Appearance; colour; size; structure
Extrinsic quality cues	Price; brand name; country of origin; nutritional information; production information
Experience quality attributes	Taste; freshness
Credence quality attributes	Healthfulness; naturalness; environmental friendliness

Intrinsic quality cues are product-related characteristics of the physical product, which cannot be changed or experimentally manipulated without also changing the physical product itself (Ophuis and van Trijp, 1995). Intrinsic quality is the most basic part of objective quality. Defined quality characteristics for an apple can be for example, size and shape, unblemished, smooth and shiny appearance and the characteristic odour, flavour, and texture of the variety measured with chemical, physical and sensory descriptive methods (Bremner, 2000). Intrinsic quality can also be called as product-oriented quality (Brunsø et al., 2002). In this thesis the intrinsic quality cues are referred to as sensory factors measured by a sensory descriptive and instrumental physical-chemical analysis.

In contrast, extrinsic quality cues involve product-related factors which are not part of the physical product; extrinsic cues can be experimentally manipulated without changing the physical characteristics of the product. Extrinsic quality cues, such as brand name and price, have an important function for a consumer in the food choice situation; they are used to form beliefs about the quality of the product, because all the intrinsic quality cues cannot be obtained prior to consumption (Brunsø et al., 2002; Steenkamp, 1990). Ophuis and van Trijp (1995) predicted the power of extrinsic quality cues and supposed that, for example, a higher price indicates high quality for a consumer between two similar products.

Referring to Figure 1 (Box 3), a consumer uses intrinsic and extrinsic quality cues that are available to form an assumption of expected quality in the food choice situation. Thereafter, during the consumption the experience quality attributes, e.g. taste, are evaluated (Ophuis and van Trijp, 1995). The credence quality attributes, instead, that are believed to be associated with the product remain many times without confirmation even after normal use for the consumer. The distinction between quality evaluation processes before and after the purchase plays a major role in the Total Food Quality Model, whereas consumer research has traditionally been biased towards analysing quality perception processes only before the purchase (Brunsø et al., 2002). When a consumer enjoys the product he compares its experienced quality to expectations (Fig. 1: Box 5). A confirmation of expectations leads to satisfaction and probably to a repeated product use

(Deliza and MacFie, 1996). However, the experienced quality is also influenced by many factors besides the product itself, such as situational factors (Brunsø et al., 2002).

## **2.4 Healthfulness of food**

Food healthfulness is a credence quality attribute (Table 1). Health has been rated as one of the most important food choice motives (e.g. Connors et al., 2001; Lindeman & Väänänen, 2000; Steptoe et al., 1995) However, even if consumers argue that health is an important factor in their food choices, it seems to be partly contradictory with their behaviour, because the number of adults, adolescents and children suffering from obesity has at least doubled in the last twenty years (International Association for the Study of Obesity, 2009; Jolliffe, 2004; Kautiainen, 2005; Reilly, 2005). According to the International Obesity Taskforce (IOTF), prevalence rates of overweight adults (BMI 25-29.9) vary globally between 4 and 56% and obesity prevalence (BMI 30+) between 1-46% (International Association for the Study of Obesity, 2009). The percentage of overweight or obese adults in the European Union (EU27) varies between 35-69% of the population. Nutrition is a major modifiable determinant of chronic diseases, with scientific evidence showing that alterations in diet have major effects on health and on the risk whether or not an individual will develop diseases, such as asthma, cancer, cardiovascular disease and diabetes in later life (Reilly, 2005; WHO, 2003). Ford et al. (2009) showed that people who do not smoke, have a BMI<30, perform physical activity 3.5 h/wk and have a high intake of fruits, vegetables and whole-grain bread and low meat consumption, have a 78% lower risk of developing chronic disease than people behaving in the opposite way. Abdominal adiposity appears to be central to the metabolic syndrome, which is associated with an approximate doubling of cardiovascular disease risk and a 5-fold increased risk for incident type 2 diabetes mellitus (Cornier et al., 2008). Lifestyle modifications and weight loss should be at the core of treating and preventing metabolic syndrome.

### **2.4.1 Healthy diet**

In order to obtain a healthy life, we need to pay attention to our diet. European people characterize a healthy diet as being low in fat, balanced, varying in content and containing fruit and vegetables (Lappalainen et al., 1998; Lyly et al., 2004). Finnish subjects (n = 125)

have stated that if they changed their diet to a healthier one, they would eat less sweet delicacies, less fat, and more vegetables and fruit (Lyly et al., 2004).

Dietary recommendations are set for the population for the prevention of diet-related chronic diseases. These nutrition intake goals are presented in Figure 2 together with nutrient intake figures of the adult Finnish population in 2002 and 2007 (Findiet 2002; Findiet 2007).

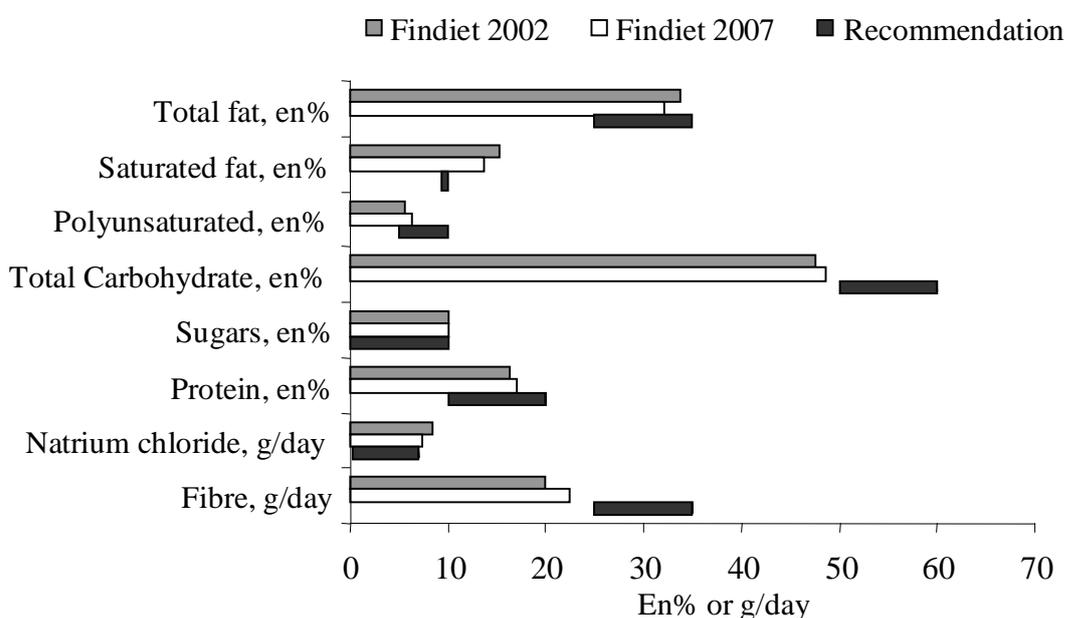


Figure 2. The nutrient intake of Finnish compared to Nordic nutrition recommendations (Findiet 2002 and 2007; Nordic Council of Ministers, 2004).

Finnish diet does not fully meet the dietary recommendations (Fig 2). According to the National Findiet studies, the intake of saturated fat and salt is higher, whereas the intake of carbohydrate and fibre is lower than the Nordic nutrition recommendations. The consumption of sugars is at the upper limit of the recommendation. Furthermore, the diet of Finnish preschool aged children (0 to 6 years) contains too much sucrose, salt and saturated fat, and too little polyunsaturated fat (Kyttälä et al., 2008). It is recognized that high intakes of free sugars threaten the nutrient quality of diets by providing significant energy without specific nutrients. Diets that are limited in free sugars have been shown to reduce total energy intake and weight loss (Smith et al., 1996). Children with a high

consumption of soft drinks rich in free sugars are more likely to be overweight and to gain excess weight (Ludwig et al., 2001).

Consumers, at least in Europe, seem to believe that a healthy diet can prevent obesity and diseases. Holdago et al. (2002) and Lappalainen et al. (1998) found that Europeans believe that a general healthy nutrition has a positive effect on staying healthy and on the prevention of diseases. In addition, people do know that increasing physical activity, eating more fruit and vegetables, and decreasing their intake of fatty foods can reduce their personal risk of type 2 diabetes or heart disease (de Almeida et al., 2006). Sun (2008) indicated that subjects (total n = 456) who are concerned about developing diseases or consuming too many calories emphasise health in their food choice motives and consciously make an effort to have a healthy diet. Moreover, Kearney et al. (2001) showed that subjects (total n = 1256) who stated that they make conscious efforts to try to eat a healthy diet also had the lowest fat (% of total energy) consumption and the highest fruit and vegetable consumption rates. However, it still seems that it is difficult to move from thoughts to action in acquiring healthier eating habits in general.

#### **2.4.2 Barriers to a healthy diet**

Studies have shown that the main barriers to change a diet toward healthier are a lack of personal motivation, information, knowledge, time and self-control (not willing to give up foods that a respondent finds pleasant) (de Almeida et al., 2006; Lappalainen et al., 1998). Furthermore, male gender and a low education level have been shown to increase the resistance to change eating habits towards a healthier one (Holdago et al., 2000). For adolescents, the most important barriers to adopting or maintaining healthy dietary choices are a lack of willpower, no time to plan healthy meals, problems in sticking to a diet, ignorance about the energy content of foods, and peer and parental influences, for example difficulties in choosing foods when out with friends (Milligan et al., 1997; Stevenson et al., 2007). Stevenson et al. (2007) found that the young (n = 73) polarize foods easily into tasty, gratifying energy-dense foods and tasteless healthy foods. Similarly, adult consumers have argued that healthier alternatives are unacceptable in taste, more expensive or take more time to prepare (Chambers et al., 2008; Connors et al., 2001).

Connors et al. (2001) found that when people are making food choices, the health motivation is frequently in conflict with taste, cost and convenience. However, the researchers found that people can constantly balance conflicting motivations during a meal, during a day, throughout a week and even over their lifetime. For example, people can balance an unhealthy snack with more careful eating during the rest of the day, or they can let themselves relax during weekends and then try to eat healthier during weekdays.

A barrier to attaining a healthier diet can also occur if people perceive their own diet quality to be better than it actually is. Over 70% of Europeans, mainly from Italy and Greece, believed that they do not need to make changes in their diet as they are already eating healthily enough; in contrast, the corresponding rates in Finland, Sweden and Denmark were about 20% of respondents (Lappalainen et al., 1998). Kearney et al. (2001) called this an optimistic bias. Kearney et al. (2001) found that 43% of the Irish respondents in the lowest quartile of vegetable intake perceived that they eat about the right amount of vegetables. Similarly, Lyly et al. (2004) showed that self-administered estimation about fibre intake has a tendency to overestimate the intake. Of those who estimated their fibre intake to be adequate/maybe adequate, only slightly over half belonged to the highest fibre intake group, and one quarter actually had a poor or insufficient intake of fibre. This misperception may prevent the actual necessary dietary changes.

Furthermore, there are barriers toward healthier eating habits related to nutrition knowledge. Arvola et al. (2007) found that subjects in Italy (n = 504) and the UK (n = 552) were less likely to make a difference between the healthiness of whole-grain and refined grain products than Finnish subjects (n = 513). Arvola et al. (2007) segmented consumers based on their beliefs of grain healthiness. Finnish consumers were overrepresented in the whole-grain favouring cluster, which was also the most health-conscious. The two other clusters, grain positive and grain neutral, considered whole-grain and refined grain as equally natural, healthy, nutritionally balanced and filling, whereas the whole-grain favouring cluster clearly rated whole-grain products higher in these characteristics. This result indicates that a barrier to whole-grain food choices is that subjects do not perceive any benefit from them compared to refined grain products. However, knowledge is not

necessarily related to behaviour. For example, Wardle and Steptoe (1991) found that university students in the UK (n = 419) do not associate health knowledge with health-related behaviour, and knowledge of the links between salt and illness, and between fibre and illness, were not linked with the frequency of adding salt to food and a conscious effort to eat fibre.

## **2.5 Effect of sensory characteristics on food perception**

Consumers frequently rank taste as the most important motive in their food choices (Eertmans et al., 2005; Honkanen and Frewer, 2009; Kearney et al., 2000; Lappalainen et al., 1998; Steptoe et al., 1995). In accordance with this, the previous chapter also showed that unacceptable taste was given as a reason for not eating a healthier diet. Overall, Olson and Jacoby (1972) hypothesized that, for most products, intrinsic quality cues have a greater effect upon quality perception of consumers than extrinsic cues. There are examples, where this hypothesis is fulfilled, for example Vickers (1993) showed that taste had a greater influence on the buying intent of yoghurt than price and brand.

When an individual starts dinner and puts a food or drink into his mouth he experiences a multitude of sensations, which provide the overall sensation called flavour. Flavour perception arises from the stimulation of taste, olfaction and the trigeminal sensory systems. Taste sensation is generated in taste receptors located in the taste buds of the tongue by non-volatile compounds dissolved in saliva, which can be classified into five basic taste qualities: sweet, sour, bitter, salty and umami. In contrast, volatile aroma compounds are perceived by the odour receptors of the nasal cavity. However, there are also some compounds that are thought of as taste compounds but have a smell and some volatile compounds have a taste (Delwiche, 2004). The trigeminal sensory system comprises chemical, thermal and tactile stimulation, for example sensory thickness, of the somatosensory system.

### **2.5.1 Influence of food composition on sensory perception**

Typically, food products contain a number of different chemical components that influence the sensory properties of the final product to varying degrees. The quantity and

composition of components can be consciously modified during food processing by the choice of ingredients and production method. It is clear that adding sucrose to water increases its sweetness, but food products are rarely so simple. Usually the prediction of the sensory properties of complex foods after modifying them with one or multiple flavour stimuli simultaneously is very challenging. Furthermore, there are some indications that the sensations of taste, smell and texture work together and influence each other in very specific ways. Therefore, the utilisation of sensory science methods in product development is advisable. A few examples of the complex system behind sensory perception are briefly covered here.

A commonly reported effect is that certain odours can modify the detection of tastants. For example, odours such as strawberry can enhance, but those of ham decrease the ratings of the sweetness intensity of sucrose (Djordjevic et al., 2004a, 2004b; Frank and Byram, 1988; Small and Prescott, 2005). Similarly, adding strawberry aroma to yoghurt is perceived to make it sweeter than one without the strawberry aroma even when the yoghurts have the same sucrose content (Saint-Eve et al., 2004). In addition, the concentration of volatiles has been found to correlate with the ratings for overall aroma in a reconstituted wine-like model with purified wine components (Jones et al., 2008). However, this is not so simple, and Jones et al. (2008) showed that the intensities of several aroma attributes were affected by three-way interaction, depending simultaneously on the concentrations of protein, ethanol, and glycerol. For example, at a lower level of volatiles, ethanol seemed to suppress the overall aroma in the absence of glycerol, but enhance it when glycerol was present. The most definitive evidence of the complex taste odour interaction in flavour perception is the evaluation of the summation of odour and taste mixtures, when each of the individual components is presented at sub-threshold levels, but subjects are able to detect the combination. Diamond et al. (2005) found that subjects were significantly more sensitive to benzaldehyde odour detection when having a saccharin solution in the mouth compared to when there was no taste stimuli. The specificity of the benzaldehyde-saccharin pairing in enhancing sensitivity to benzaldehyde was tested by comparing it with the pairing of benzaldehyde with a monosodium glutamate taste solution, where odour sensitivity was not increased.

In addition, texture also influences taste and flavour sensations. Increasing the viscosity of solutions containing sugar, flavour volatile and varying concentrations of hydrocolloid thickeners has been found to decrease the perceived flavour and sweetness intensity (Hollowood et al., 2002). The effect has also been perceived in real food products. For example, Paci et al. (2002) and Saint-Eve et al. (2004) have shown that increasing the viscosity of yoghurts (with the addition of thickener or gentler mechanical treatment) makes the products taste less sweet.

### **2.5.2 Development of liking**

The sensory properties of food are important determinants of liking and furthermore, preferences play a central role in determining food selection and diet quality. Genetic predispositions influencing food preferences include the predisposition to prefer foods that are sweet and salty and reject those that are sour and bitter (Birch, 1999; Ganchrow and Mennella, 2003; Keskitalo et al., 2007a; Wardle and Cooke, 2008). Children and adolescents eat more of the foods they like best. Researchers have suggested that producing tasty food in a more healthy fashion, for example, by improving the taste of high-fibre products, may increase its consumption among schoolchildren and adolescents (Berg et al., 2003; Stevenson et al., 2007). In contrast, adults' taste preferences and aversions do not always directly predict their food consumption (Drewnowski, 1997).

Food use in childhood has been found to correlate positively with food practices in adult life (Unusan, 2006). Therefore, the development of healthy eating patterns during childhood may be critical in order to have healthy eating behaviour during adulthood. Children who from the earliest age have plentiful opportunities to sample a variety of healthy foods appear to have a healthier diet throughout childhood (Cooke, 2007). Birch (1999) emphasized learning via experiences in developing food preferences, because learning can transform the initial neophobic rejection of unfamiliar tastes into a preference. This is based on the frequency of exposure, the contexts and consequences of eating. For example, Forestell and Mennella (2007) showed that even 4- to 8-month-old infants who received repeated exposure to a certain food eat more of the familiar food flavour. In addition, Mennella et al. (2009) showed that infants who were introduced from early

infancy to bitter and sour tastes (fed with hydrolyzed casein formula) ate more and were more accepting of bitter and sour tasting cereals compared with infants fed on breast milk or a bovine milk-based formula. In agreement with studies above, Wardle and Cooke (2008) reported that the number of children disliking a certain food correlates strongly with the number of children who have never tried it, indicating that children who are not familiar with that food do not like it because they do not know it. Furthermore, Birch (1981) showed that presenting foods to children consistently in a positive social context enhances preferences for that particular kind of food. Verbal information and other exposure also tend to increase the hedonic ratings of novel foods among neophobic adults (Tuorila et al., 1994). Okamoto et al. (2009) showed that even the liking of solutions of basic tastes is enhanced when food-name labels, such as lemon, coffee jelly, consommé soup or caramel candy, are presented. Willingness to taste novel food can also be increased when the unfamiliar food is accompanied by a familiar food item (Pliner and Stallberg-White, 2000a & b). Pliner and Stallberg-White (2000a) showed that children were more willing to try a novel flavour of crisps when they were accompanied by a familiar dip flavour than when the crisps were served alone. This resembles the term flavour principle, which was conceptualized by Elisabeth Rozin (Rozin and Rozin, 1981), where adding a culturally important seasoning ingredient can be used to facilitate the introduction of a new food staple into a culture.

It has been found that children's and adolescents' food choices correlate highly with those of their parents. Søndergaard and Edelenbos (2007) showed that parents are well aware that children prefer familiar foods, but at the same time parents considered health very important when making food choices for their family. Parents determine the availability of food within the household, offer exposure and positive reinforcement to various foods and act as examples of dietary behaviour. For example, Neumark-Sztainer et al. (2003) found that fruit and vegetable intake is associated with taste preferences, which correlates furthermore with the availability of fruit and vegetables in the home. Similarly, Berg et al. (2003) found that eleven- to fifteen-year-old secondary school students (n = 181) were reported to consume bread and breakfast cereals with more fibre than those they perceived as tasty themselves. For some participants, this consumption pattern resulted from restricted access. De Bourdeaudhuij and Van Oost (1998) showed that a high level of

family cohesion, which means strong emotional bonding between family members together with stability and regularity in roles and rules, induced healthy eating habits in adolescents. The findings suggest that parental involvement is desirable in health promotion interventions.

However, parents have to be careful in how they are persuading children to eat e.g. vegetables. Birch (1999) describes how giving food for children as rewards for approved behaviour enhances the preference for that reward food, and in contrast, when children are offered rewards for eating a food, the food eaten to obtain rewards become less preferred. This indicates that when parents use energy-dense foods as treats for eating vegetables as they do according to Stevenson et al. (2007), they reinforce the liking of treats and decrease the liking of vegetables. In addition, evidence indicates that strategies that restrict children's access to snack foods actually make the restricted food more attractive, as indicated by the children's greater selection and intake of restricted than unrestricted foods (Birch, 1999). In this light, it is easy to interpret the results of Åstrøm and Rise (2001), who found that perceived behavioural control (the subject's own control over eating healthy food in future) had the strongest influence on young adults' (25 years old, n = 735) decision to eat healthily.

### **2.5.3 Interaction between sensory perception and food intake**

All the five senses are important in the perception of enjoyable food. According to Shepherd (1999), the ability to perceive a food's sensory characteristics determines whether a person will consume the food. However, a person's ability to perceive flavour can vary for different reasons. Increasing age has been showed to decrease odour detection and identification, and taste and texture perception scores (Koskinen and Tuorila, 2005; Schiffmann and Graham, 2000; Zandstra and de Graaf, 1998). Furthermore, older adults with olfactory dysfunction have shown less interest in food-related activities, they have a lower preference for fruits, vegetables and whole-grain breads and a higher intake of sweets (Duffy et al., 1995). A few studies have examined the differences in sensitivity and preference to basic taste qualities between overweight and normal-weight individuals. Simchen et al. (2006) found that overweight subjects ( $BMI \geq 28$ ) were less sensitive in

odour identification and detection and taste perception compared to normal-weight subjects (BMI < 28). Moreover, adiposity of adults has been shown to correlate positively with the rated pleasantness of the fat content of foods (Mela and Sacchetti, 1991), but not with the pleasantness of sugar concentrations (Drewnowski, 1997). However, an association between adiposity and the liking for fatty or sugary foods has not been found in children aged 7-9-years old (Hill et al., 2009). Hill et al. (2009) suggested that children's obesity is not driven by a greater liking for energy-dense food than the general enjoyment of food and snacking. To sum up, the relationship between adiposity and preferences are not yet clear. However, a better understanding of preferences of overweight subjects could be helpful in diet monitoring and in the development of healthy products that are liked better.

## **2.6 Effect of product-related non-sensory factors on food perception**

Product-related non-sensory quality cues in food perception are called extrinsic cues (Table 1). The most common extrinsic quality cues are brand name, country of origin, price, and store name. Nutrition information and nutrition claims are cues which provide the information about healthfulness of food. Extrinsic factors generate expectations that can influence consumer behaviour and either perception of product quality, purchase intention or product selection (Deliza & MacFie, 1996).

### **2.6.1 Brand name**

A brand consists primarily of a brand name and/or logo with the power to differentiate the product from other competitive products, as well as to help motivate consumers in choosing the product, thus making them satisfied and loyal. People are intended to form preferences among brands and create emotional bonds to them, demonstrating their brand loyalty in repeated product purchases. A brand can be the main reason for the purchase of a particular food product (Vranesevic and Stancec, 2003). Therefore, strong brand names are treasures for a company and sometimes they are the most valuable assets (Kohli and Thakor, 1997).

McClure et al. (2004) showed that strong preferences among brands could even be measured as brain responses using functional magnetic resonance imaging (fMRI). In the study, the research group found that Coca-Cola brand information significantly influenced subjects' (n = 67) preferences. First, they determined the subjects' preferences for Coke and Pepsi, both by asking and in a blind taste test. Then the subjects tasted soft drinks during fMRI scanning both blind and branded. The research group observed significantly greater brain activity in the hippocampus, dorsolateral prefrontal cortex (DLPFC) and in the midbrain when the Coca-Cola brand was made known to the subjects compared to the blind taste test. The hippocampus and DLPFC have both been previously implicated in modifying behaviour based on emotion and affect.

One of the most debated marketing failures is also related to Cola-Cola. In 1985, the Coca-Cola Company developed a new Coke that consumers preferred in extensive blind taste tests to both Pepsi Cola and the old Coke formula. However, when the new Coke was launched it did not gain popularity as expected and within three months of introducing the new Coke and ending production of the original formula, the company was forced to bring the original formula back (Dubow and Childs, 1998; Veryzer, 2003). It seems that the emotional attachment to brand equity had a bigger influence than blind taste in this case. However, Coca-Cola and Pepsi are special cases and people may display very strong subjective preferences for one or the other.

Often, it has been found that brand information increases the liking ratings in taste tests compared to blind tasting (Cho et al., 2005; Di Monaco et al., 2003). Although there are also studies where the information has had no effect on liking or buying intent (Vickers, 1993). Allison et al. (2004) showed that the amount of information (blind compared to flavour description and full concept) had no significant effect on the overall liking ratings of breakfast cereals but in contrast, there was an increased liking of cheese crackers among teens aged 12-15 years old (n = 300). Thus, the effect of information seems to be product dependent but other factors may also have an influence. For example, Akbay et al (2005) found that higher-income consumers are more inclined to purchase national brands than lower-income consumers who purchase lower-priced private label brands. The effect of brand will depend on the consumer.

### **2.6.2 Country of origin**

Sometimes consumers base their trust in food safety and their risk-reduction strategy heavily on the country of origin. Kim (2008) found this to be the case among Japanese consumers (n = 728), who are generally known as sophisticated and highly conscious of food quality, especially when making choices for the purchase of meat. Kim (2008) found that Japanese meat products were estimated to have a 5.4% price premium, compared with products imported from the US. On the other hand, some products may even gain a benefit from being an imported product. Guinard et al. (2001) found that upon finding out the origin of the lager beers they tasted, some consumers in the USA lowered their liking ratings for domestic beers, and in contrast, raised their ratings for imported beers.

### **2.6.3 Price**

Price is an important food choice motive, especially for younger consumers and people with a lower socio-economic status (Drewnowski, 2009; Glanz et al., 1998; Hupkens et al., 2000; Steptoe and Wardle, 1999). Overall, healthier food has been shown to cost more; the price of a calorie has been shown to be substantially cheaper when obtained from unhealthful, energy-dense foods, instead of from more healthful foods (Drewnowski, 2009). Therefore, an important question for public health promotion efforts in healthful food choices is, “Can people be influenced to consume healthier foods if the prices for these foods are lowered?” French (2003) indicated that price reductions are an effective strategy to purchase of more healthful foods and showed, for example, that a 50% price reduction increased the sales of fresh fruit four-fold in secondary school cafeterias among adolescents, whereas sales returned to a baseline level with the reinstatement of usual prices. Similarly, Epstein et al. (2006) found that raising the price of healthy or unhealthy foods resulted in decreased purchases of those foods among youth. Di Monaco et al. (2005) found that increasing the price significantly reduced the likelihood of Finnish students buying a bar of chocolate. However, small changes in prices originating from taxes or subsidies have not been found to produce significant changes in consumption and obesity (Powell and Chaloupka, 2009).

#### **2.6.4 Nutrition information**

Nutrition information could assist consumers to observe the nutritional content of the food product and to make informed choices for healthy options. Grunert and Wills (2007) defined nutrition labelling as an attempt to provide consumers, at the point of purchase, with information about the nutrition content of individual food product. In the European Union, nutrition labelling is currently not compulsory unless a nutrition claim is made (Evira, 2009). In addition, the manufacturer can choose from two groups of nutrition labels; the shorter version includes energy value, amounts of protein, carbohydrate and fat, and the longer version includes additional information about fibre, sodium and saturated fat.

Several studies have shown that consumers do not seem to fully understand or have sufficient knowledge to evaluate the nutritional quality of food products (BEUC, 2005; Cowburn and Stockley, 2005; van Kleef et al., 2007). This is a considerable barrier to the effective use of nutrition information on food labels. The reasons for not reading nutrition labels are the lack of time, the size of print on packages and a lack of understanding of the terms. The consumers who are more likely to read labels are mainly women, have higher incomes and/or higher level of education, have small children, or a positive attitude to diet and health and are from Nordic countries, the Netherlands or the UK rather than from France, Greece and Spain (Cowburn and Stockley, 2005; Feick et al., 1986; Grunert and Wills, 2007).

Cowburn and Stockley (2005) suggested that consumers have difficulties in understanding the role that the different nutrients mentioned on the labels played in their diet. They found that most consumers claimed to look at nutrition labels often or at least sometimes. Most often people have been reported to pay attention to the price, best before date, brand name and volume information rather than nutrition information during shopping (BEUC, 2005; Gracia et al., 2009). Many respondents rated nutrition information lower than information on the origin and the best before date, but still among the top five wanted in labels (Grunert and Wills, 2007). However, Grunert and Wills (2007) estimated that consumer interest in nutrition information is growing.

One example showing poor nutritional knowledge comes from a European study, where a product that had a very high sugar content was presented to consumers (n = 3000). It was found that only one fifth of consumers were sceptical about the nutritional quality of the product while 12% believed it was nutritionally very good and 54% believed it was rather good (BEUC, 2005). In addition, Enneking et al. (2007) studied the effect of information concerning sweetening alternatives in carbonated soft drinks on preferences (n = 621). They found that 100% sugar was preferred over conventional sweeteners and a new diet sweetener mixture in most cases.

### **2.6.5 Nutrition and health claims**

A nutrition claim means any claim which states, suggests or implies that a food has particular beneficial nutritional properties due to the energy or the nutrients it contains, whereas a health claim means any claim that states, suggest or implies that a relationship exists between food and health (European Parliament, 2006).

Studies are not fully consistent with the effects of nutrition claims on pleasantness or on the buying interest of food products. Clearly, the results obtained are dependent on the product type tested as well as the question asked (hedonic response versus behavioural acceptability). For example, in a study of Stein et al. (2003), health-related information did not have an effect on the hedonic ratings of a bitter beverage, but did tend to increase acceptability. Therefore, they suggested that studies looking at the influence of nutrition claims should measure both sensory judgements and consumption/acceptance. In addition, there seems to be a certain change from more negative findings to more positive between studies carried out during the 1990s and studies carried out during the 2000s. This could be due to at least two reasons. Firstly, product development has been done successfully, and for example, low-fat or high-fibre products nowadays have reasonably good sensory properties. Secondly, consumers may be changing and becoming more health conscious in general. However, Tuorila and Cardello (2002) showed that consumers do not accept clear off-flavours, even if the product has been claimed to have a health benefit. This indicates that the health claim does not compensate for a poor taste.

The effects of a nutrition claim on the pleasantness or buying interest of real food products have shown mainly negative influences in studies by e.g. Kähkönen and Tuorila (1999), Wardle and Solomons (1994), Vickers (1993), whereas positive findings are reported by e.g. Baixauli et al. (2008), Ginon et al. (2009), Johansen et al. (2009), Kähkönen and Tuorila (1999) and Roosen et al. (2007). Vickers (1993) found that subjects had the highest buying intent for yoghurt products labelled as “all natural”, less buying intent for the low-fat claim and the least for the no fat – sweetened with aspartame for strawberry yoghurts. Wardle and Solomons (1994) showed that low-fat labelled cheeses and yoghurts were rated lower in liking than foods labelled as full-fat. Kähkönen and Tuorila (1999) showed that the nutrition claim on reduced fat-content decreased the expected pleasantness of yoghurts and chocolate bars, and the buying probability of chocolate bars compared to regular-fat samples, but increased the buying probability of margarines. However, in another study of Kähkönen et al., (1997) the fat-free claim had no effect on the actual pleasantness of yoghurt. In addition, Johansen et al. (2009) have studied the effect of information about fat and sugar content on the liking and purchase probability of yoghurts. They found that information about the fat content had no significant effect, but health conscious consumers (n = 153) increased their hedonic ratings and buying intent when information about low sugar content was given. The effect of nutritional information on behaviour can also be studied in other ways than asking about the hedonic response or buying intent. For example, Provencher et al. (2009) found that female subjects (n = 99) ate 35% more oatmeal and raisin biscuits when the biscuit was described as a healthy snack than when it was presented as a new gourmet biscuit (unhealthy). This indicates that perceiving a food as healthy can increase the intake of that food.

However, studies that have segmented consumers based on their age, gender or attitudes have found more effects of nutrition claims. Shepherd et al. (1991/2) detected that there is a difference between different types of people in what kind of impact the nutrition claims have. They identified that information about sweeteners (sugar versus aspartame) and fat content (full versus low-fat) did not affect the liking and likelihood of buying flavoured milk samples in the overall group of subjects (n = 60). However, when the subjects were divided on the basis of attitudes towards low- and full-fat milks, the presentation of information increased the liking and likelihood of buying full-fat samples and decreased

the liking and likelihood of buying low-fat samples for those with an attitude preference for full-fat milk (n = 19), while those with attitude preferences for low-fat milk showed the reverse effect (n = 32). In addition, Enneking et al. (2007) showed that when analyzing the whole consumer group (n = 621), low-calorie sweeteners had a clear negative effect on consumer choices compared to a 100% sugar-sweetened carbonated soft drink. However, they found that subjects who judged themselves as calorie-sensitive (34% of the total group) preferred low-calorie sweeteners over pure sugar if the products were clearly indicated as calorie-reduced products. Furthermore, Ginon et al. (2009) showed that when a French baguette was labelled as a source of fibre, consumers (n = 123) were ready to pay more for it. In agreement with previous studies, this effect was the strongest among the oldest participants, who were also more concerned about fibre in their diet. In addition, nutrition claims can reduce food neophobia and increase the willingness to try novel foods in certain consumer segments (McFarlane & Pliner, 1997). The researchers found that the general claim “good for you” increased the willingness of younger subjects (aged 14-22; n = 101) to try novel foods, such as lotus root or octopus. However, subjects between 23 and 40 (n = 84) needed a more specific nutrition claim that foods were “low fat” to increase their willingness to try novel foods, whereas in the oldest subjects (aged 40-76; n = 73), willingness was independent of nutrition claims. In general, information that a novel food was “good for you” resulted in a greater willingness to try novel food among subjects for whom nutritional considerations were more important than in those for whom they were not.

These studies indicate that the effect of information is dependent on the product as well as on demographic variables and the degree of health concern. Furthermore, van Trijp and van der Lans (2007) showed that there are differences between countries in how consumers perceive nutrition- and health-related claims. Moreover, other extrinsic information such as price can complicate influences related to nutrition claims. Bower et al. (2003) studied the willingness of consumers to pay more for the fat spread ‘Benecol’, which has a proven health benefit. They found that when the health claim was shown together with the price information, respondents (n = 70) were not ready to pay a higher price. Respondents were more willing to buy ‘Flora’ spread than Benecol because of its lower price, good sensory appeal and general healthiness. However, females, older subjects and those with higher

levels of health concern were less negative toward the Benecol label. In summary, there is still little insight into how labelling information is used in real-world shopping situations, and how it affects the dietary patterns of the consumer.

## **2.7 Effect of consumer-related factors on health food perception**

Several research examples have indicated that consumers are different in their likes, in the way extrinsic factors are processed and finally, in their food choices. This section discusses several consumer-related factors that may influence the differences between consumers.

### **2.7.1 Genetic variation**

Genetic variation in taste perception has been shown to contribute some differences in food preferences and food use, particularly regarding fruits and vegetables (Keskitalo et al., 2007b; Wardle and Cooke, 2008). This genetic variation may explain food intake and therefore, a few example studies are mentioned here. The most studied compounds in this research field are phenylthiocarbamide (PTC) and 6-*n*-propylthiouracil (PROP), which have a bitter taste and where the subjects' ability to taste these compounds is known to be genetically based. Higher sensitivity to PROP has been associated with a lower consumption of vegetables, and the dislike of the taste of e.g. raw broccoli, raw spinach and American cheese, in children (Bell and Tepper, 2006; Keller et al., 2002; Turnbull and Matisoo-Smith, 2002) and with tasting a higher bitter intensity from vegetables in adults (Dinehart et al., 2006). Also, TAS2R bitter receptor genotypes have been shown to influence the perceived bitterness of vegetables (Sandell and Breslin, 2006). However, there are also studies where the relationship between PROP taster status and the intake of bitter plant food and beverages has not been detected (see for example Yackinous and Guinard, 2002).

### **2.7.2 Age**

There is considerable evidence that the age of the individual is associated with health-related attitudes. Chambers et al. (2008), Hearty et al. (2007), Kearney et al. (2000) and van den Bree et al. (2006) have shown that older subjects are more willing to make an effort to eat a healthy diet than younger subjects. In addition, the way a healthy diet has

been perceived as important may also be age-dependent. For example, Zunft et al. (1997) found that younger subjects (15-34 years old) considered fitness and weight control as the important consequences of a healthy diet, whereas with increasing age (over 35 years) more people tended to believe that healthy eating could help them to stay healthy and prevent diseases. Similarly, Roininen et al. (1999) found that older subjects were more interested in health and natural diet than younger subjects. In general, Prescott et al. (2002) found that older consumers considered health, natural content, familiarity, as well as ethical concerns, to be more important food choice motives than younger consumers did.

### **2.7.3 Gender**

Numerous studies have shown significant differences between genders in the importance of food healthiness. Generally, females show more a positive attitude towards trying to eat a healthy diet and consider it as a more important food choice motive compared to males (Hearty et al., 2007; Kearney et al., 2000; Roininen et al., 1999). Furthermore, females also tend to believe that healthy eating yields more benefits than do males in EU countries, according to Zunft et al. (1997). Rozin et al. (1999) found that females both in the USA, Japan and Europe pay more attention to reduced fat/salt foods and are more worried about the fattening effect of food than males are. In agreement with previous studies, Wardle and Steptoe (1991) found that female university students were more likely to diet than males. Females have been found to assign significantly more importance to weight control and health, as well as to natural content, ethical concerns, price and sensory appeal than males do (Lindeman and Väänänen, 2000; Pollard et al., 1998). For males, the pleasure of eating is the most important factor, according to Roininen et al. (1999). In addition, Pettinger et al. (2004) found that convenience was more important to males than to females. Wadolowska et al. (2008) showed that females more often seek novel healthy products and take care of their health than males. In addition, females are more positive about ingredients such as high fibre, protein and potassium content in breakfast cereals (Lee et al., 2007). In addition, the research group showed that females, unlike males, found healthy breakfast cereal with low sugar, low fat and low calorie to be very important.

The eating habits have also been found to differ between females and males. Females eat less cake, fewer crisps, less red meat and add less salt to meals, and furthermore, they consciously try to avoid fat and cholesterol and eat more fibre and more fresh fruits than males (Pollard et al., 1998; Wardle and Steptoe, 1991). Biloukha and Utermohlen (2000) showed that Ukrainian females (n = 616) also like the taste of apples, green vegetables, and candy more than males (n = 303), whereas males prefer the taste of fatty and processed meats, whole milk, lard, pasta and cola drinks. Furthermore, females rated vegetable salad and apples as generally healthier compared to males.

Even in the case of children, boys and girls have been found to be different. Kopelman et al. (2007) found that boys aged 9-11 (n = 254) had significantly poorer knowledge than girls (n = 222) of what foods were healthy. Boys have shown a higher liking for fatty and sugary foods than girls (Hill et al., 2009).

### **2.7.3 Socio-economic status**

The education level has been found to correlate with the motivation toward healthy eating behaviour and the perceived importance of diet healthfulness (Hearty et al., 2007; Kearney et al., 2000). People with a tertiary level of education seem to believe that healthy eating habits are connected with a better quality of life, disease prevention and weight control, whereas people with primary education only are much more sceptical (Lawrence et al., 2008; Zunft et al., 1997.) Lower-educated women also perceive healthier food as more expensive (Lawrence et al., 2008), which has in fact been proved to be true. For example, Andrieu et al. (2006) showed that lower-cost diets tend to be energy-dense but nutrient-poor, whereas nutrient-dense diets cost more. Therefore, socio-economic status plays a significant role in food choice decisions and diet quality (Akabay et al., 2005; Darmon and Drewnowski, 2008; Steptoe and Wardle, 1999; Turrell, 1998). In addition, low socio-economic status has been linked to higher obesity rates in the developed countries (Drewnowski, 2009; Reilly, 2005). Steptoe and Wardle (1999) showed that people with a lower socio-economic status place more emphasis on price and familiarity than people with higher status. Lower-income consumers shop more carefully in order to maximize their spending power and purchase more private labels and larger size packages of national

brands (Akabay et al., 2005). Steptoe and Wardle (1999) summed up that low-income families buy foods that are higher in calories but low in nutrition in order to satisfy hunger better. Family dinners may also be different between high and low socio-economic groups. For example, Lawrence et al. (2008) found that women of a lower socio-economic group receive no support from their families in their attempts to feed them a healthier diet. Furthermore, children whose parents were unemployed were found to be likely to consume significantly more sweets, fried food and fizzy drinks compared to those whose parents were employed (Kopelman et al., 2007). In the same study, children of unemployed parents had a poorer knowledge of healthy foods than children with employed parents. Low socio-economic subjects have been found to consume less skimmed milk, high fibre products, fruit and vegetables than high socio-economic groups (Steptoe and Wardle, 1999). Deshmukh-Taskar et al. (2007) found that young adults aged 20-38 years (total n = 1266) with over 12 years education had higher consumption of cereals, dairy products, fruits and vegetables than less educated subjects. Furthermore, Turrell (1998) showed that subjects in the low socio-economic group disliked the taste more and had a lower intent to purchase many of the healthy foods, for example, whole-grain bread, unsweetened juice, low-fat yoghurt, low-fat minced meat, low-fat cheese and whole-grain pasta than the high socio-economic group. As the reason for this diversity, Turrell (1998) suggested that high socio-economic groups has been the most receptive to health promotion messages about recommended dietary practices and that low socio-economic groups may have had limited exposure to healthy food, which has hindered the development of preference. However, Drewnowski (2009) blames the higher costs of healthy food as the main reason why subjects with lower incomes do not have access to it.

#### **2.7.4 Cultural factors**

Culture is an important determinant of food choice and it has also a considerable effect on how people perceive the health benefits of healthy food. Nowadays when markets are becoming increasingly international, exporters should be aware of the substantial differences between different cultures. For example, the French and Belgians have been found to emphasize the pleasure and social aspects of eating, but also healthiness when choosing their food (Pettinger et al., 2004; Rozin et al., 1999). British consumers, instead,

emphasize convenience and organic/ethical issues, whereas Americans associate food with health and worry about weight and modify their diet in the direction of what they perceive as healthy. However, ironically, while the Americans derive less pleasure from food they also consider themselves to be less healthy eaters than the French (Rozin et al., 1999). Rozin et al. (1999) suggest that the different historical causes of food cultures between the Americans and French may be one reason for this contradiction; the French have emphasized high quality, whereas the Americans have emphasized high quantity.

The widely-used Food Choice Questionnaire offers an opportunity to compare differences in food choice motives between countries. Europeans, Canadians and New Zealanders have shown similar motivations and have rated sensory appeal, health, natural content and price to be among the most important motives (Eertmans et al., 2006; Honkanen and Frewer, 2009; Lindeman and Väänänen, 2000; Prescott et al., 2002). In comparison, Prescott et al (2002) found that the most important motives for the Japanese were price and natural content, whereas Chinese subjects from Taiwan and Malaysia emphasized natural content, health and weight control, and rated sensory appeal rather low. However, the FCQ has received criticism that different measuring items are not understood in the same way in different cultures after translation (Eertmans et al., 2006; Fotopoulos et al., 2009).

Moreover, there is evidence that preferences for flavours can vary between cultures. Prescott and Bell (1995) found product-dependent differences in hedonic responses, and showed that, for example, the Japanese and the Australians differ in their liking of the sweetness and saltiness intensity of different products. The researchers suggested that the reason might be related to familiarity and exposure to the food context. Therefore, preferences for flavours within food cannot be generalized cross-culturally. However, Lawrence et al. (2007) showed that ethnic minority groups assimilate the food culture of their country of residence into their eating habits rather quickly. They showed that subjects from Pakistan, Zimbabwe and Somali changed their eating habits, for example, eating fewer vegetables and moving toward the fast-food aspect of the British diet. The reasons may include the increased price of familiar vegetables, lack of availability and time to prepare their traditional dishes. They also found that the environment influences health

concerns and that after settling in the UK the immigrants started to worry about their body image.

### **2.7.5 Values**

Values can be defined as beliefs about some desirable end-state that transcends specific situations and guides selection of behaviour (Schwartz, 1992; Figure 3). A person's set of values can play a very important role in his consumption activities. It is commonly believed that causality flows from values through attitudes to behaviour, and not the other way around. This means that values have an impact on attitudes, which in turn influence people's behaviour. Brunsø et al. (2004) detected that values influence how people perceive and experience food in their everyday life. They showed that people who represented the Schwartz value domain "universalism" (expressing concern for nature and welfare) considered a healthy diet, meaning no additives and organic products, to be very important in their food choices. Similarly, Worsley and Skrzypiec (1998) found that a concern for nature as a personal value was directly associated with the safety and quality aspects of food as well as the concern about hidden additives in foods. Furthermore, Dreezens et al. (2005a, 2005b) and Saher et al. (2006) showed that self-transcendence values, such as universalism, are related to negative attitudes towards genetically modified and positive attitudes towards organically grown foods. In addition, Bech-Larsen and Grunert (2003) found that a positive attitude towards functional foods was related to the value dimension of "openness to change". Sometimes personal values have been found to explain behaviour more strongly than demographic variables (Worsley and Lea, 2003). Worsley and Lea (2003) studied the relationship among personal values and trust and usage of nutrition information sources. They detected that subjects representing "power" values (expressing authority, wealth, social power) used and trusted mass media sources more. In contrast, subjects representing "hedonistic" (enjoying life) and "universalistic" values (world of beauty, unity with nature, inner harmony), in turn, used more health and women's magazines as their sources for nutrition information and had trust in specialist media, but not in mass media.

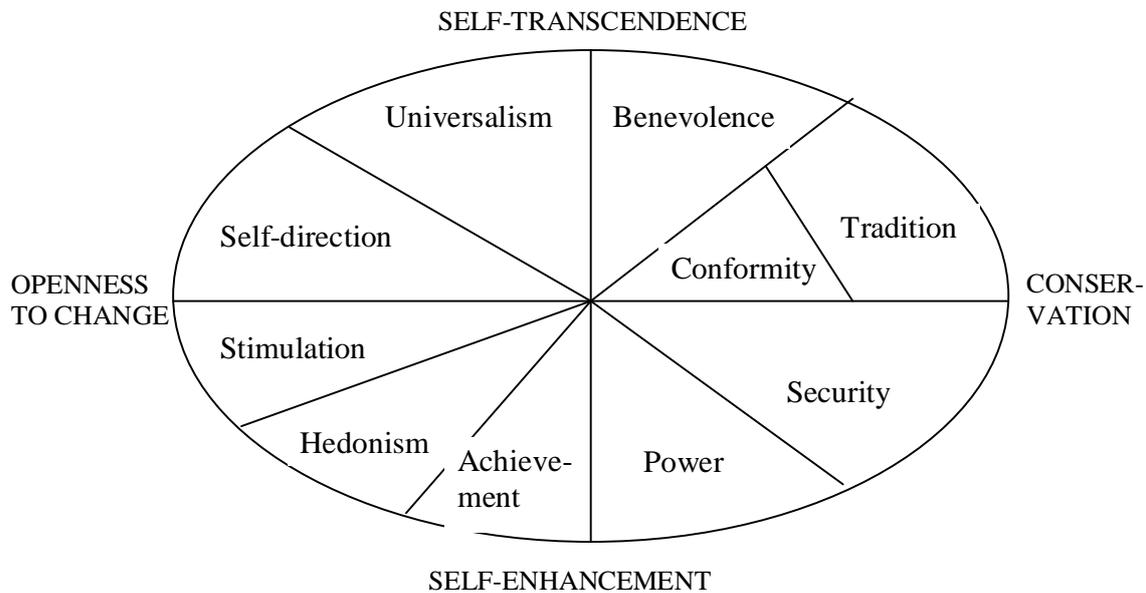


Figure 3. Model of relations among motivational types of values and bipolar value dimensions according to Schwartz (1992).

### 2.7.6 Attitudes

Consumer populations are increasingly segmented on the basis of their food orientations, particularly attitudes (Roininen et al., 1999). It seems that a healthy diet goes hand in hand with a positive health attitude. Subjects with a positive attitude towards health have been shown to prefer and consume significantly greater amounts of whole-grain bread, fruit and vegetables, yoghurt and fish, and in comparison, lower amounts of white bread, whole milk, butter, crisps, alcohol, sugars, confectionary and red meat than subjects with a more negative attitude (Hearty et al., 2007; Neumark-Sztainer et al., 2003; Pollard et al., 1998; Steptoe and Wardle, 1999; van den Bree et al., 2006; Wadolowska et al., 2008; Zandstra et al., 2001). For example, van den Bree et al. (2006) showed that people who constantly monitor and control their food intake and body weight also have healthier eating patterns measured in terms of the frequency of eating fruits, vegetables, high-fibre grains and fish. Furthermore, Wadolowska et al. (2008) showed that consumers with pro-health food choice motives more often consumed food that complies with dietary recommendations and also had a higher preference for those foods. Moreover, Roininen et al. (1999) showed that subjects with a positive attitude toward General health interest rated non-fat milk and reduced-fat cheese as healthier, and full-fat milk, full-fat chocolate bars, full-fat cheese and

soft drinks as less healthy than subjects with negative attitudes toward General health interest.

So, where does the positive health attitude come from? Health attitudes can be changed through nutrition knowledge, the role of incentives (e.g. communication of physical benefit) or using persuasive communication via the media. For example, Acharya et al. (2006) showed that various promotional activities, such as in-restaurant promotions or media advertising, had an effect on healthy dining and increased the probability of a consumer purchasing a healthy menu item significantly. When a person is more knowledgeable about food and health, he or she can identify more healthy aspects as argued in Sijtsema et al. (2002). For example, Wardle et al. (2000) showed that individuals (n = 1040) who had high nutrition knowledge were 25 times more likely to meet current dietary recommendations than those in the lowest knowledge quintile. However, always the results of studies focusing specifically on the effect of nutrition knowledge on the eating behaviour of adolescents have not been clear (Berg et al., 2002; Pirouznia, 2001), indicating that the connection may be weak and depend on the food product studied as well as the research method.

Zandstra et al. (2001) suggested that, for nutrition education and product marketing purposes, it is highly important to segment consumers on the basis of their attitudes. Product marketing could exploit consumer segmentation to develop and produce food products that appeal to different groups with different attitudes and lifestyles. Furthermore, nutrition education can be more effective when the messages are segmented for specific target groups (Geeroms et al., 2008). A better understanding of the factors that motivate individuals to health-related behaviour could help to design more effective nutrition campaigns and advertising. Geeroms et al (2008) showed that for subjects who perceive health as a matter of having more energy, transformational/self-directed advertising containing vivid images expressing movement and vitality are the most appropriate; for subjects who perceive health mainly in terms of physical appearance (staying slim, looking good) an informational/self-directed advertising strategy with verbal arguments focusing on outward appearance is the most appropriate; and for subjects who perceive health mainly in terms of emotional well-being, advertisements should focus on achieving a

complete and happy life with family and friends and avoid focusing too much on functional aspects (Geeroms et al., 2008).

## **2.8 Context effect**

The context of food choice and consumption is a determinant which cannot be ignored. Health food may be perceived as more suitable at breakfast at home than during a gala dinner. Generally speaking, the same food item may taste different in different contexts. Research suggests that there are at least four major context effects that influence the perception of food product during consumption: the presence of other food items, the presence of other people, freedom of food choice, and the environment in which food is selected and consumed (Meiselman, 2002). An example of the context effect is also the experience of flavour because the same olfactory input is experienced in different ways depending on whether the odour originates in the mouth (retro-nasally) or nose (orthonasally) (Rozin and Tuorila, 1993). King et al. (2004) found that context variables influence product acceptance but that the relationship between effect and acceptance is not consistent within and across all different food products. The research group found, for example, that social interaction with strangers had a negative effect on the acceptance of pizza and a free choice of meal components had a positive effect on the acceptance of salad, but a neutral effect on the acceptance of pizza. Later, in a more detailed study, King et al. (2007) found that the overall acceptability scores obtained in natural restaurant serving conditions were significantly higher than the scores of the traditional central location test. The context of the meal, the consumer's ability to choose and a natural eating situation with friends had the strongest positive effect on acceptance ratings. In agreement with previous studies, Åstrøm and Rise (2001) found that adolescents are more likely to eat healthily if they perceive that a salient in-group would provide normative support for healthy eating. Similarly Birch (1980) showed that children's food choices, preferences and consumption patterns are strongly influenced by other children and that a child, accompanied by peers, would also choose and consume initially non-preferred vegetables. Furthermore, other role models can induce children to consume food, but the effect is dependent on the relationship between the child and the model. Older children are more effective role models than younger ones; mothers more effective than strangers, and for

older preschool children, adult heroes were more effective models than more ordinary adults (Birch, 1999).

Overall, the context effect is one of the big questions in sensory food science. Do hedonic sensory evaluations conducted in a laboratory setting tell the truth about product choices and liking at all? A laboratory setting represents the most controlled environment for testing, but rarely corresponds with the real eating situation. Therefore, the predictive validity of these tests on the consumption and long-term acceptability in free-living situations has been questioned. But do central location tests or home use tests produce “the right” answers any better because of all the noise. Artificial settings are always somehow artificial and do not fully correspond with the real choice or eating situation. Therefore it is advisable, if possible, to apply multiple approaches to understand the influence of a context factor (Hersleth et al., 2005; Jaeger and Rose, 2008). If different methodological approaches produce similar results, then the findings may be considered reliable. For example, Hersleth et al. (2005) found that the testing location, between laboratory setting, central location and home, did not have a significant effect on the hedonic liking of cheeses. However, Jaeger and Rose (2008) used a labelled stated choice experiment where they described different eating occasions to consumers. They found that the stated eating occasion had a significant effect on fruit choice behaviour.

## **2.9 Concluding remarks**

There is broad scientific evidence that different consumer- and product-related factors as well as the context have a very complex effect on the degree of liking, acceptability and choice of food products (Figure 4). Even a small change in one variable can lead to a totally different outcome. Many of the publications reviewed here have had a focus on one isolated relationship rather than in examining the interaction between different factors that influence food consumption behaviour. As Köster (2009) demanded, more interdisciplinary research is needed in order to understand the determinants of eating behaviour and the prediction of food choice by the consumer. In order to guide people’s food choices toward healthier options, people should be more conscious of the effects of dietary choices on their health and have the knowledge how to use nutrition information in

their food choices. In addition, the healthful food products should be considered as pleasant and the purchasing of healthful food should be perceived as cost-effective. Finally, understanding the divergence of consumers can lead to more competent product development and nutrition education.

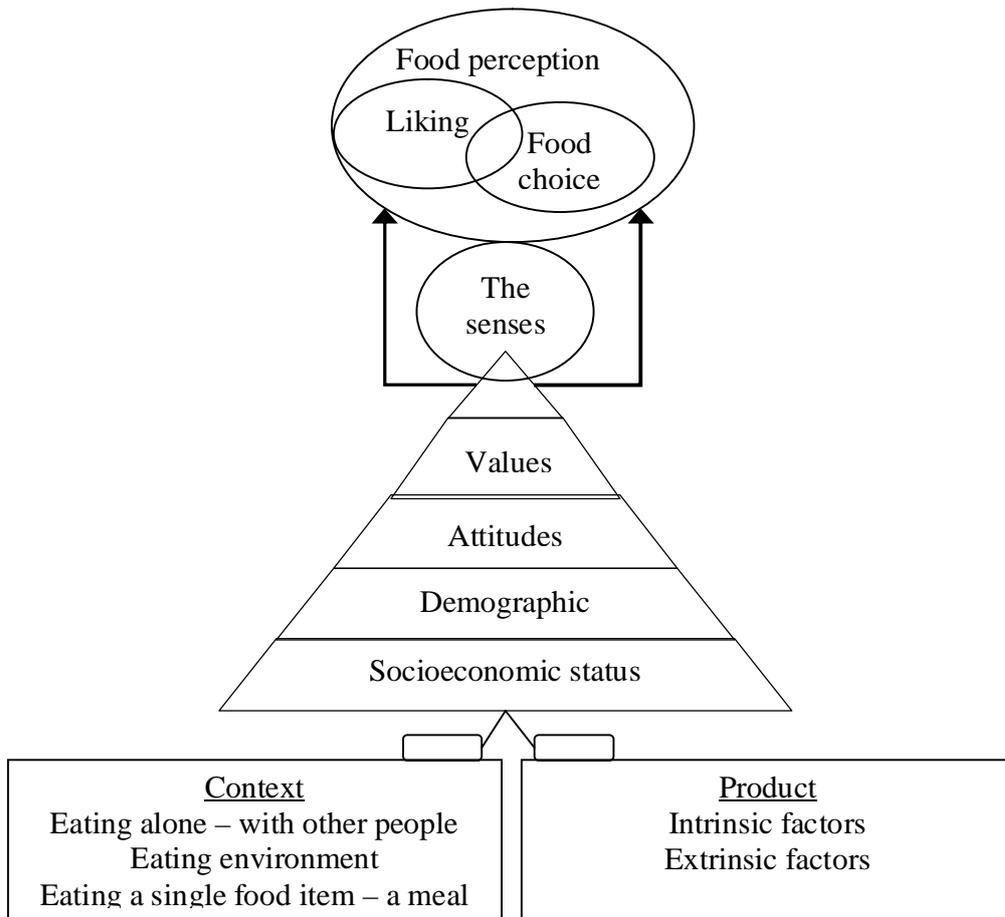


Figure 4. Different factors behind food perception.

## **3 AIMS OF THE STUDY**

### **3.1 Overall aim**

The overall aim of this study was to characterize the interactions between sensory characteristics, chemical quality and degree of liking of healthy model foods when the variation in consumer-related factors and product information were taken into account. This overall aim was achieved through four sub-aims.

### **3.2 Sub-aims**

The first sub-aim was to investigate the effects of product composition on sensory characteristics in bakery and beverage products considered as healthy (Publications I, II).

The second sub-aim was to investigate the effect of several intrinsic factors on the liking of healthy model foods (Publications II, III, IV).

The third sub-aim was to investigate the effect of non-sensory product information on liking of healthy model foods (Publication III).

The fourth sub-aim was to investigate the effects of consumer characteristics, such as personal values, food choice motives and demographics, on the liking or food choice of healthy model foods (Publications III, IV, V).

## **4 MATERIALS AND METHODS**

### **4.1 Food samples**

Four types of samples were used in the studies (Table 2): flaxseed bakery products (I), wellness drinks (II), drinking yoghurt (III) and rye bread (IV, V). All other samples were commercial apart from the flaxseed bakery products, which were developed for the study. Flaxseed and flaxseed oil were used to enrich the nutritional quality of bakery products. Flaxseed rolls contained whole flaxseeds and crushed flaxseed, while cinnamon rolls were fortified with flaxseed oil and crushed flaxseed.

### **4.2 Consumer tests**

#### **4.2.1 Participants**

Original publications II-V include consumer tests, whereas the degree of liking of flaxseed bakery products has been published elsewhere by Pohjanheimo and Mäkinen-Aakula (2004) (Table 2). For studies II-IV, consumers were recruited mainly from companies and educational institutes in the Helsinki Metropolitan Area. Interested consumers filled in a background questionnaire on the Internet. Recruiting yielded a pool of 1124 volunteers (aged 15-76) from which participants were chosen for each study using a utilization rate of the product under the study as a criterion. All participants signed a form where they accepted that the information and answers they gave were collected for research purposes. For study V the consumers were recruited from two schools in Western Finland.

Table 2. Aims, samples and participants of studies I-V.

Study	Aims	Samples	Consumers	Trained sensory panel
I	To study the effects of flaxseed on bakery products, and the relationships between sensory and instrumental texture properties.	A bread roll fortified with flaxseed A cinnamon roll fortified with flaxseed A bread roll without flaxseed (control)	N = 46* (range 20-61 y)	N = 15
II	To study the relationships among headspace volatiles, sensory quality and liking of wellness beverages in different consumer groups.	‘Light pineapple, LP’ (a low-calorie beverage); ‘Fruity fibre, FF’ (a beverage fortified with fibre and vitamins); ‘Energising cranberry, EC’ (an energising beverage fortified with caffeine); ‘Light fruit, LF’ (a low-calorie beverage)	N = 192 (F 78%, M 22%, mean age 37.8 years, range 18-76 y)	N = 30
III	To study the effects of sensory quality, product information, and consumer characteristics on the liking of drinking yoghurts.	A Finnish strawberry drinking yogurt A Finnish raspberry-blueberry drinking yogurt A Czech strawberry-banana drinking yogurt A Czech raspberry-blueberry drinking yogurt	N = 162 (F 82%, M 18%, mean age 36.2 years, range 15-63 y)	N = 10
IV	To study the effects of values on food choice motives and on the liking of rye bread.	Finnish flat rye breads E1, E2 and F1	N = 224 (F 85%, M 15%, mean age 35.4 years, range 15-63 y)	N = 11
V	To study adolescents’ attitudes toward rye bread and its healthiness.	Flat rye bread Oat bread A white roll	N = 61 F 66%, M 34%, mean age 13.5 years, range 13-14 y)	-

\*Results of the consumer study published in Pohjanheimo and Mäkinen-Aakula (2004).

#### 4.2.2 Hedonic scaling

In studies II-IV the degree of liking was evaluated using a labelled affective magnitude (LAM) scale (Cardello and Schutz, 2004; Schutz and Cardello, 2001). The LAM scale (Figure 5) was chosen for its improved discriminatory capacity and ability to reduce the central tendency and the end effects that can occur when using the 9-point hedonic scale. The LAM scale has showed equal reliability and greater sensitivity compared to the 9-point hedonic scale (Greene et al., 2006). However, the method has been identified to be slightly more difficult to use by consumers, but similar conclusions have been reached when determining the degree of liking regardless of the scale used (Hein et al., 2008).

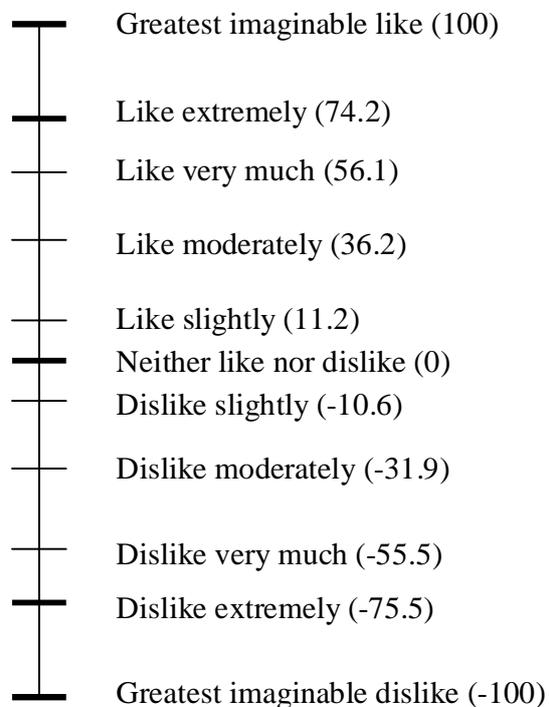


Figure 5. The labelled affective magnitude (LAM) scale developed by Schutz and Cardello (2001) was used to evaluate pleasantness in studies II-IV.

Hedonic responses were collected in two parts from the consumers participating in studies II-IV. First, consumers evaluated pleasantness while the food samples were coded with 3-digit numbers (blind evaluation) within the product category of wellness beverages, drinking yoghurts or rye bread. After this and other activities lasting about a half an hour, subjects re-evaluated the pleasantness in another test room, while the same

samples were coded with product information (e.g. brand name and nutritional information). The results from both of these evaluations are published in study III, but the results obtained for wellness beverages and rye breads are also covered in this thesis.

Hedonic scaling for bakery products containing flaxseed (Study I) was conducted using the nine-point hedonic scale. A small consumer group (n = 46) participated in the test and the results have been published by Pohjanheimo and Mäkinen-Aakula (2004).

#### **4.2.3 Qualitative consumer test**

A qualitative consumer research method was used in study V. Qualitative consumer tests are used to understand motivations and opinions that are believed to be relevant for the issues under study. Focus group discussion is centred on the group interaction of a small group; they encourage participants to respond to, and question, one another (Krueger, 1994). Less verbally intense discussion and more naturalistic methods, such as activities including drawing, completing activity sheets, etc., have been suggested for children's focus groups compared with adults' focus groups (Kennedy et al., 2001). Therefore, during the discussion session, the participants were asked to make a breadboard using the modified stacking box methodology presented by Jonsson et al. (1998). In addition, a choice task between rye bread, oat bread and a white roll was conducted and participants were asked to choose the bread sample they wanted to consume during the discussion.

#### **4.2.4 Questionnaires**

Four different questionnaires, namely the Schwartz Value Survey, Food Choice Questionnaire, Concern Scale and General Health Interest, were used to classify the participants' values, attitudes and motives in studies II-V.

The Schwartz Value Survey (Schwartz, 1992) has been demonstrated to be a cross-culturally valid instrument for measuring personal value priorities. This survey contains 56 different values organized in ten domains (Fig. 3). A shorter version of the Schwartz Value Survey (Schwartz, 1994; IV: Table 1) was used in original publication IV to divide the participants into three groups according to their responses. Subjects who scored the

highest on the hedonistic items and low on traditional items were chosen for the hedonistic group (n = 65) and, in turn, subjects who scored the highest on the traditional items and low on hedonistic items were chosen for the traditional group (n = 51). In addition, a control group (n = 108) was built up from subjects outside these value groups. Subjects participating in studies II and III also filled in the Schwartz Value Survey and their results have been used in the Results part of this thesis.

The Food Choice Questionnaire (FCQ) consists of thirty-six items designed to assess the reported importance of nine motives related to food choice (Steptoe et al., 1995). These factors are health, convenience, price, sensory appeal, natural content, mood, familiarity, ethical concern and weight control. In the FCQ, the subjects were asked to evaluate and rate the statement “It is important to me that the food I eat on a typical day ...” for each item using a 7-point scale ranging from “disagree strongly” to “agree strongly”, and the factor scores were calculated as the mean of three to six items related to each factors. The FCQ was used in original publications III and IV, and in addition, data was collected from subjects participating in study II.

The Concern scale used in original publications II-IV (developed by Kähkönen et al., 1996) contained nine items related to a subject’s concern about possible unhealthy ingredients in food and the perceived risk of certain diseases. The subjects were asked to rate their opinions in response to the question: “When thinking about your own health, how concerned are you about the following issues?” on a 9-point Likert scale and the scale score was calculated as the mean of ratings given for the statements.

The General health interest scale is a subscale of the Health and Taste Attitude questionnaires (Roininen et al., 1999), which measures consumers’ interest in eating healthily using eight statements. Each of the statements was evaluated using a 7-point Likert scale and the scale score was calculated as the mean of ratings given for the statements. The General health interest scale was used in original publication V.

### **4.3 Descriptive analysis**

For studies I-IV, the sensory profiles of the samples were obtained using generic descriptive analysis by sensory panels of 10-30 assessors (Table 2). The general guidelines for the selection, training and monitoring of assessors (ISO 8586-1) were used. During the training sessions, the assessors were familiarized with the usage of attributes and the intensity scale. The intensities of each attribute were scored on a line scale of 10 cm using Compusense five software (version 4.1.2, Compusense, Guelph, Canada) for data collection. The sensory profiling took place in the sensory laboratory of the Functional Foods Forum, which is in accordance with the ISO 8589-1988 standard.

### **4.4 Physical-chemical measurements**

Some standard methods were used to compare the differences between sample varieties inside a product type. In study I, the texture was measured instrumentally and fatty acids profile, fibre, seciosolarisiresonil diglycoside, and cadmium content were analyzed to define intrinsic product characteristics of bakery products baked with and without flaxseed. In study II, the headspace volatile compound analysis was carried out by gas chromatography–mass spectrometry (GC–MS) using the solid-phase microextraction technique (SPME). Odour activity values (OAV) were used to assess the contribution of a single compound to the overall aroma. In addition, pH and Brix were measured from the products in studies II-IV.

### **4.5 Statistical analysis**

The data were analyzed using statistical procedures as described in the original publications (I-V).

The Statistical Package for the Social Sciences (SPSS version 11.0-16.0, SPSS Inc.) was used to perform difference tests between the samples/consumer groups and in correlation analyses. One-way analysis of variance (ANOVA) was performed to test for differences between the consumer segments in terms of liking. A two-way ANOVA was performed to test for differences between three or more samples in descriptive analysis where both

attribute and session effect were taken into account. If significant differences were found in ANOVA, the differences were further tested with Tukey's or Tamhane's test ( $p < 0.05$ ). For comparison of the differences between two groups, an independent samples T-test was applied. The paired samples T-test was used to analyse the effect of product information between two different hedonic evaluation conditions. Pearson's correlation was used in correlation analyses.

The Unscrambler 9.0-9.8 (Camo AS, Oslo, Norway) was used in multivariate data analysis. Principal component analysis (PCA) involves decomposing one data matrix,  $X$ , in order to explain a more relevant co-ordinate system. In studies I, III and IV it was used to interpret the sensory attributes in relation to sample differences. Two-way partial least squares (PLS) regression is a multivariate tool for obtaining multivariate models relating an independent set of variables  $X$  to a dependent data set  $Y$  (Lengard and Kermit, 2006). In study II, PLS regression was used to extract and identify volatile compounds that correlate best to the sensory attributes, as well as identifying sensory and chemical attributes that explained hedonic responses. Furthermore, L-PLS regression relates three blocks of data forming an L-shape. L-PLS is a relatively new method introduced by Martens et al. (2005), where the sensory variables are used as independent  $X$ -variables and the hedonic ratings and the correlations between consumer background information and hedonic ratings are used as dependent  $Y$ -variables. For the L-PLS method, the consumer background information was treated as categorical and converted into binary form according to the importance of each food choice motive scale value (low, moderate or high importance).

## 5 RESULTS

### 5.1 Effect of sensory-factors on health food perception

#### 5.1.1 Relationships between sensory and chemical-physical characteristics

Modifying product composition by adding flaxseed ingredients was found to influence both the sensory and physical-chemical characteristics of bread rolls. Fresh flaxseed bakery products were described as moist, soft and springy in their sensory texture characteristics. It was found that flaxseed fortification reduced hardening and drying significantly compared to the control bread baked without flaxseed ingredients (I: Fig. 2). Flaxseed rolls and cinnamon rolls had a higher fat content compared to control rolls; the most abundant fatty acid in flaxseed bakery products was  $\alpha$ -linolenic acid compared with typical breads where fatty acids are saturated. However, this did not generate any significant changes in the intensity of the fat off-flavour during storage (I: Table 3) and the mean liking of flaxseed bakery products was between 6 and 7 on the 9-point hedonic scale, indicating moderately pleasant products (Pohjanheimo and Mäkinen-Aakula, 2004). The physical measurements of the texture complemented the sensory method; the instrumentally measured texture of springiness and hardness were found to correlate significantly with the corresponding sensory characteristics.

The ingredient composition used in wellness beverages had a significant influence on the sensory and chemical characteristics of the products and the beverages were perceived as different according to several measured parameters (II). PLS regression analysis was performed in order to relate sensory and chemical data sets. In total, the biplot (II:Fig. 2) explained 65% of the chemical measurements (X variables) and 91% of the sensory attributes (Y variables). It can be seen that, for example, tropical fruit odour and fruity flavour were explained by headspace volatiles 3-methylbutyl acetate (which has a fruit-like odour), butyl acetate (a pear-like odour), and linalool (a citrus-like odour). The evaluated sourness was better explained by pH than by titratable acidity (II: Fig. 3). Fortifying beverages with vitamins, minerals and other compounds can create a variety of off-flavours. In this study, the 'Fruity fibre, FF' beverage containing calcium was found to be less fresh in odour. Freshness correlated negatively with 2-heptanone, which has a

soap-like odour and was present only in 'Fruity fibre, FF' beverage (II: Fig. 2). The taste of calcium has been described as smooth and flat, and its odour as soapy (Tordoff, 2001).

### **5.1.2 Relationships between sensory characteristics and hedonic responses**

The results of the consumer tests showed that intrinsic product characteristics were found to explain hedonic responses (II: Fig. 4; III: Fig 1-3; IV) and food choice (V). In the following, the effects of sensory-factors on hedonic responses averaged over all participants are explained. In study II (n = 192), the most liked wellness beverage was the 'Light pineapple, LP', which was rated significantly higher on the liking scale than the other samples ( $F(3, 771)=7.1, p < 0.001$ ). The intensity of the evaluated citrus-like odour, derived from  $\alpha$ -pinene, ethyl hexanoate, hexyl acetate, 3-hexenol, 3-hexenyl acetate and butyl hexanoate, and the evaluated freshness, derived from 1-hexanol and nonanal, were found to positively influence the overall liking of wellness beverages, indicating that a citrus-like odour and freshness were important sensory attributes in wellness beverages for consumers. All the wellness beverages had the same level of sweetness intensity. In study III (n = 162), the most liked drinking yoghurt was the raspberry-blueberry flavoured Czech yoghurt. It differed from the other three drinking yoghurts significantly ( $F(3, 639)=7.0, p < 0.01$ ) in liking. The intensity of the evaluated smoothness and sweetness, and the Brix value were found to be high in the Czech raspberry-blueberry drinking yoghurt (III: Fig. 1). In contrast, sourness and thickness correlated negatively with the most liked yoghurt. In study IV (n = 224), the rye bread 'F1' was rated the highest on the liking scale although the differences were rather small between the samples ( $F(2,670)=3.6, p < 0.05$ ). 'F1' did not differ significantly from 'E2' in liking, but the rye bread 'E1' was evaluated less pleasant. The sensory characteristics of rye bread that appealed to the consumers the most were the low intensity of overall odour and flavour, as well as the low intensity of rye-like and brown-like flavours. In study V, 65% of the young people chose the flat rye bread, a fifth chose the white oat bread and only a tenth chose the white wheat roll when the adolescents were asked to choose bread they would like to eat during the focus group discussion. Overall, the participants mentioned soft texture and expected taste sensation as the most important reasons for their bread choices.

The results from studies II-IV above were extracted from the overall liking scores that the participants gave for the samples they evaluated. However, during the hedonic test the consumers were asked to evaluate the pleasantness of some other sensory attributes as well. Here, the data of the studies II-IV was used to calculate the importance of different sensory attributes, such as appearance, odour, taste and mouth feel on the overall liking scores. Table 3 represents the variation of correlations in different product types. Correlation coefficients clearly show that taste had the strongest impact on the overall liking in all product groups. In drinking yoghurts, the mouth feel seemed to have stronger correlation on the overall liking than odour, whereas in rye bread the odour correlated more strongly with the overall liking than the appearance did.

Table 3. Variation of correlation coefficients (Pearson's) between hedonic scores given to appearance, odour, taste and mouth feel, and overall liking in four different wellness beverages (n = 192), in four types of drinking yoghurt (n = 162) and three types of rye bread (n = 224).

	Appearance	Odour	Taste	Mouth feel
Wellness beverage		0.64-0.74	0.90-0.94	
Drinking yogurt		0.51-0.73	0.89-0.94	0.73-0.84
Rye bread	0.49-0.57	0.60-0.74	0.89-0.91	

All correlations were significant at least at the  $p < 0.01$  level.

## 5.2 Effect of non-sensory factors on hedonic responses

The results of the consumer test in study III showed that extrinsic factors i.e. product-related non-sensory factors significantly affected the hedonic responses of drinking yoghurt. Information concerning the manufacturer's name, brand name, flavour and picture of the commercial package, which revealed the country of product origin, significantly increased the liking of Finnish yoghurts (III: Table 3). In contrast, the effect of the same type information on the liking for the Czech yoghurts was not significant, whereas it also increased the overall liking. In addition, study III showed that the product information had a different impact on the different age groups. The product information had a significant effect ( $p < 0.05$ ) on the liking scores for Finnish yoghurts and clearly a non-significant effect ( $p = 0.91-0.93$ ) on the liking scores for Czech yoghurts in the oldest

age group (aged between 42 and 63). In contrast, the product information did not significantly alter any liking scores given by the consumer group aged 28–41 years old.

The effects of product information concerning wellness beverages or rye bread were not covered in original publications II and IV, but the data was collected and it is shown in Figure 6 and published in Paasovaara et al. (2007). The product information presented for consumers evaluating wellness beverages (n = 192) was the product label of a commercial bottle, which contained the manufacturer’s name, brand name, flavour, and nutrition information (II: Table 1). It can be seen in Figure 6 that product information had an influence on the overall liking of wellness beverages. The effect was significant (p < 0.01) in three beverages, which contained added vitamins and other added components with a certain function, for example fibre to promote bowel health or caffeine to refresh. The only beverage where the information had no effect on liking was the ‘Light fruit, LF’ beverage, which had no specific function claimed for wellness apart from low-calorie content. Product information given for the rye bread contained the brand label. This information significantly increased (p < 0.05) the liking for all three rye bread samples evaluated. Furthermore, the impact of product information was different on different consumer segments within these products (Paasovaara et al., 2007).

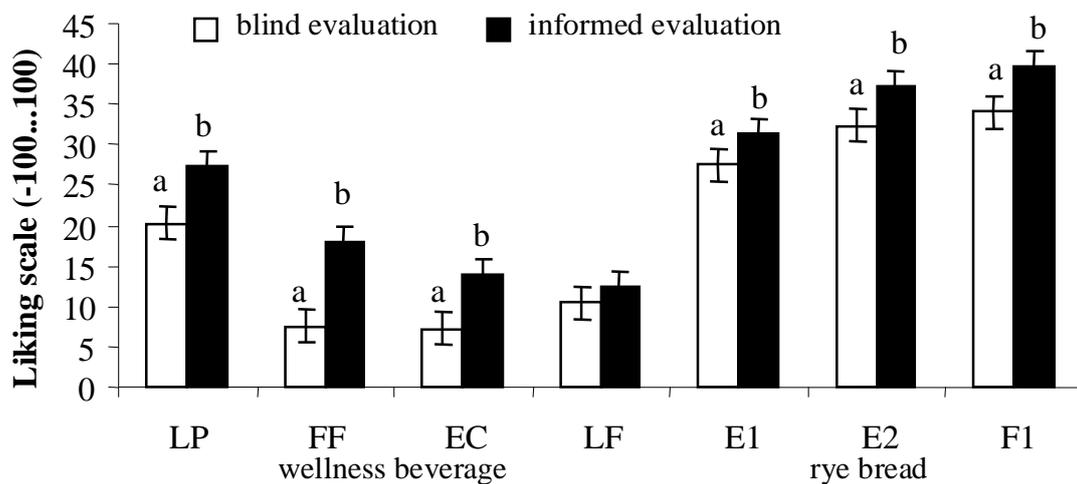


Figure 6. The effect of product information on the average liking scores (n = 192) of four wellness beverages (LP = Light pineapple, FF = Fruity fibre, EC = Energising cranberry, LF = Light fruit) and average liking scores (n = 224) of three types of rye bread E1, E2 and F1. The letters a-b indicate the significant difference (p < 0.05) between the means.

Study V showed that Finnish adolescents were well aware of the health benefits of rye bread. The fibre content of bread was seen as an indicator of healthiness, even if it was not considered to direct food choices among adolescents. Only a few participants mentioned the product labels as a source of nutrition information about the bread. On the contrary, intrinsic factors, such as bread colour, were seen as more important indicators of bread healthiness for the adolescents. The adolescents discussed their intent to purchase snack food during school hours and argued that they would be interested in purchasing rye bread sandwiches for a snack if the price were equal to that of chocolate bars, which were popular snacks at that time.

### **5.3 Consumer-related factors in health food perception**

#### **5.3.1 Relationships among demographics, food choice motives and values**

Qualitative consumer study (V) showed that Finnish adolescents (13-14 years old) recognize health as a noteworthy motive for their food choice. The young considered rye and other whole-grain breads to be healthier than refined bread, and stated that healthy bread fills the stomach better, and is not fattening to the same extent as white bread. This shows that the knowledge of health and weight control evolve at an early age. Similarly, study III showed that food choice motives related to health and weight control were also important for the youngest participants (under 28 years old) (III: Fig 3). This can also be observed in Table 4, where the consumer background data from studies II, III and IV has been combined. The youngest age group considered “health” as equally important a food choice motive as the oldest age group (over 42 years old) did. However, concern about health and food measured with the Concern scale was found to increase significantly with age ( $F(2,348)=32.9, p < 0.001$ ) (II; III; Table 4). Moreover, the importance of other food choice motives was found to vary according to age as well. Older subjects rated “natural content” and “ethical concern” significantly more important than younger subjects, whereas “price” and “mood” were more important for the youngest subjects (III: Fig 3; Table 4). Age was closely related to education and the youngest consumers had more often only secondary education while older consumers (over 28) had a university degree. In addition, personal values were found to be associated with age, and the traditional subjects were significantly older than hedonistic subjects (IV: Table 3).

Gender was found to be closely associated with health interest in adolescents and with the importance of health and weight issues in adults. Study V showed that already at the age of 13–14, girls showed more interested in health than boys measured on the General health interest scale ( $U = 191, p < 0.01$ ). Girls also argued more often that healthfulness is an important motive for them in food choices, and connected healthiness to weight control. The same trend was apparent with adult participants (III and Table 4). Female participants rated the “health”, “weight control”, “convenience”, “natural content” and “ethical concern” FCQ subscales and Concern scale as significantly more important compared with males.

Overall, the most important food choice motive measured with FCQ in our population was sensory appeal (Table 4). Health and price shared the second position, whereas convenience, natural content and weight control were experienced as equally important after them.

The effect of personal values on consumers’ food choice motives was measured in study IV. Food choice motives were found to vary between traditional and hedonistic consumers. Traditional subjects considered the “natural content” ( $F(1, 115) = 6.4, p < 0.05$ ), “familiarity” ( $F(1, 114) = 9.1, p < 0.01$ ), “ethical concern” ( $F(1, 114) = 5.2, p < 0.05$ ) and concern about food and health ( $F(1, 114) = 13.4, p < 0.001$ ) to be significantly more important food choice motives for them than hedonistic subjects did. All the same differences between value groups were also apparent in Table 4, where the data of all subjects ( $n = 354$ ) participating in studies II-IV is combined.

Table 4. Means and standard deviations of FCQ subscales and the Concern scale in a combined population (n = 354), between genders, age groups and personal values of studies II, III and IV.

Food choice motive	Total n = 354	Gender		Age			Personal value		
		Female n = 284	Male n = 70	≤27 n = 101	28–41 n = 132	42≥ n = 121	Control n = 140	Hedonism n = 113	Tradition n = 101
Health	5.2±0.9 (II)	5.2±0.9a	4.9±1.0b	5.2±1.0 $\underline{ab}$	5.0±1.0 $\underline{a}$	5.4±0.9 $\underline{b}$	5.1±0.9	5.1±1.0	5.3±1.0
Mood	4.6±1.1	4.6±1.0	4.4±1.0	4.8±1.0 $\underline{a}$	4.4±1.0 $\underline{b}$	4.5±1.1 $\underline{b}$	4.5±1.0	4.7±1.0	4.5±1.1
Convenience	4.9±1.1 (III)	5.0±1.1a	4.5±1.2b	5.0±1.1	4.8±1.2	4.9±1.1	4.9±1.1	4.9±1.1	4.9±1.3
Sensory appeal	5.6±0.8 (I)	5.7±0.8	5.5±0.9	5.6±0.8	5.7±0.9	5.7±0.8	5.4±0.8 $\underline{a}$	5.8±0.8 $\underline{b}$	5.8±0.8 $\underline{b}$
Natural content	4.9±1.3 (III)	5.0±1.3a	4.6±1.3b	4.4±1.4 $\underline{a}$	4.8±1.3 $\underline{a}$	5.5±1.1 $\underline{b}$	5.0±1.1 $\underline{a}$	4.5±1.5 $\underline{b}$	5.3±1.3 $\underline{a}$
Price	5.2±1.0 (II)	5.3±1.0	5.1±1.2	5.6±1.0 $\underline{a}$	5.0±1.1 $\underline{b}$	5.0±1.1 $\underline{b}$	5.3±1.0	5.3±1.1	5.1±1.2
Weight control	4.9±1.4 (III)	5.0±1.3a	4.3±1.6b	4.8±1.4	4.7±1.4	5.0±1.3	5.0±1.3	4.8±1.5	4.9±1.3
Familiarity	3.6±1.3	3.7±1.4	3.5±1.2	3.8±1.3	3.5±1.4	3.7±1.3	3.6±1.3 $\underline{a}$	3.3±1.3 $\underline{a}$	4.0±1.4 $\underline{b}$
Ethical concern	4.4±1.4	4.5±1.4a	4.1±1.4b	4.0±1.5 $\underline{a}$	4.3±1.3 $\underline{a}$	4.8±1.3 $\underline{b}$	4.3±1.3 $\underline{a}$	4.0±1.5 $\underline{a}$	4.9±1.4 $\underline{b}$
Concern scale	5.8±1.5	5.9±1.5a	5.5±1.8b	5.2±1.4 $\underline{a}$	5.6±1.5 $\underline{b}$	6.7±1.4 $\underline{c}$	5.8±1.5 $\underline{a}$	5.4±1.6 $\underline{a}$	6.4±1.4 $\underline{b}$

The number in parentheses after the total population signifies the order of importance. Significant differences ( $p < 0.05$ , Tukey) between genders or age groups or value groups are marked with different letters a-c.

### **5.3.2 Relationships among sensory characteristics, consumer-related factors and hedonic responses**

Participants who were concerned about their health rated the wellness beverages as more pleasant (II: Fig. 3) than unconcerned participants. The participants who were unconcerned about their health found only 'Light pineapple, LP' beverage moderately pleasant, whereas other beverages were rated as "neither like nor dislike" on the liking scale. Furthermore, concern about health correlated with the liking for less sweet and sourer yoghurts (III: Fig. 3). The participants who were unconcerned about their health evaluated the overall liking for the Czech strawberry-banana drinking yoghurt as significantly ( $F(2, 157) = 4.3, p < 0.05$ ) more pleasant than participants who were moderately or highly concerned about their health. The Czech strawberry-banana yoghurt was evaluated as the highest in sweetness intensity and low in sourness and genuineness of flavour.

L-PLS regression analysis was used to study which sensory characteristics of products, as well as consumer background characteristics, could explain hedonic responses. A correlation loading plot in study III (III: Fig. 3) gives a visualisation of the systematic covariation among sensory and consumer characteristics and hedonic responses. It is evident that there is a large variation in hedonic scores between the participants. The first two principal components explained 93% of the sensory attributes (X variables) and 74% of the liking (Y variables). Participants who rated "health", "sensory appeal", "natural content" and "ethical concern" as important food choice motives rated sourer and less sweet Finnish raspberry-blueberry and Finnish strawberry yoghurts to be more pleasant than subjects who scored low on the previous motives. In comparison, the high degree of liking for the sweetest yoghurt (Czech strawberry-banana) correlated with food choice motives "convenience", "price", "mood" and "familiarity". In addition, this diversity of preferences in yoghurt quality related to sweetness and sourness, and food choice motives were supported by sweetness adequacy evaluations using the JAR scale (III). Consumers who found the existing sweetness levels of these yoghurts as too high were found to rate "natural content" and "ethical concern" as a significantly more important food choice motives compared with consumers who found the existing sweetness levels rather low.

An L-PLS regression was constructed for the combined data containing the hedonic responses of 354 subjects who participated in studies II-IV (Fig. 7). Here, the sensory profile, containing a matrix X (4 types of yoghurt, 4 wellness beverages, 3 types of rye bread, 18 sensory attributes), the hedonic responses in a matrix Y (354 consumers) and the background characteristics of the consumers in a matrix Z (354 consumers, 30 background variables) were combined into a single overview model. This overview plot allows us to see the main inter-disciplinary relationships between the sensory attributes and the background correlations and helps us to explain the difference between the participants segmented based on their hedonic scores. The plot shows the first two PLS-components, which represent 88% of the variance in the independent X-variables (sensory attributes of the products) and 48% of the variance in the dependent-combined YZ-variables (hedonic responses together with the consumer-related factors). The mean liking score is situated near the origin. However, the plot shows that the participants had very different likings because they (little spots presenting the participants) are spread all over the loading plot. A segment of participants located on the left side of component 1 liked the two Finnish yoghurts and 'Light fruit, LF' wellness beverage most. The Finnish yoghurts were characterised by the sensory properties of thick texture, sour and genuine flavour, whereas the Light fruit beverage was characterised as sour, astringent and berry flavoured. Participants with the highest liking scores for these three products considered "natural content", "health" and health concern as important food choice motives and had a university or polytechnic education (edu3). On the right side of the component 1 is a large segment of participants with high liking scores for the two Czech yoghurts, which correlated with the sensory attributes of sweet taste, high flavour intensity and smooth texture, and the wellness beverage 'Fruity fibre, FF', which has a high overall odour intensity and fruity flavour. Participants who have the highest preference for these products are mainly under 27 years old, only have secondary school education, and consider "ethical concern", "sensory appeal" and health concern as unimportant to them, and "convenience" and "price" as important food choice motives. The drinking yoghurt, wellness beverage and rye bread intensity increased, and sourness decreased along PC1 from the left to the right. In addition, PC1 separated participants into younger (27 years or under) and older (over 28 years old). The second PC describes the variation due to



When adolescents in study V were classified according to their General health interest scores into low, moderate and high interest groups, an association with health interest and the consumption of whole-grain and rye bread was found. An adolescent showing more interest in health reported eating significantly ( $p < 0.01$ ) more rye bread ( $U = 115$ ) and other whole-grain bread ( $U = 107$ ) than adolescents with a low health interest (V: Fig. 3).

## **6 DISCUSSION**

### **6.1 Effect of sensory and non-sensory factors on hedonic responses**

One aim of this thesis was to study the effects of product composition on sensory characteristics and furthermore, on hedonic responses. In general, it has been widely proved that product composition, sensory quality and liking of the product are related. Today, the food industry faces the challenge to manufacture tasty, familiar food products in a healthier fashion more than ever before (Roodenburg et al., 2008). Improved nutritional quality can be achieved, for example, by adding vitamins, fibre or other ingredients to the products. However, the addition of these compounds may also create different off-flavours in the products. Therefore it is critical to study the impact of product composition on sensory characteristics and their connection to liking. This is justified because several studies have shown that taste is considered as one of the main barriers toward healthier choices (Chambers et al., 2008; Connors et al., 2001; Stevenson et al., 2007) and consumers are not willing to sacrifice taste over healthiness (Tuorila and Cardello, 2002).

The contribution of studies I and II is related to understanding the relationship between product composition and liking. Adding flaxseed, which is a good source of fibre, lignans and  $\alpha$ -linolenic acid, showed a significant improvement on the nutritional quality of bakery products in study I. In addition, flaxseed was found to have a positive effect on the sensory characteristics of bread. Flaxseed ingredients were not found to increase evaluated off-flavour, but instead, to retain softness and moisture during storage effectively. Additional data showed that bakery products fortified with flaxseed were evaluated moderately pleasant on the hedonic scale. Therefore, flaxseed can be

recommended for improving the nutritional value of bakery products. Study II examined the relationships among headspace volatile composition, sensory characteristics and the degree of liking for four wellness beverages enriched with vitamins, minerals and/or fibre. The mean liking of three of the four beverages were rated near “neither like nor dislike” on the liking scale, which is a rather low score for food products on the market. Peryam (1998) considered that mean liking “neither like nor dislike” is highly suspect for market acceptance. A low liking score may indicate unacceptable sensory characteristics due to the nutritional fortification. For example, we found that the wellness beverage ‘Fruity fibre, FF’, which was fortified with calcium, also contained the headspace volatile compound 2-heptanone, which has a soapy-odour. Previously, Lawlor et al. (2002) and Flores et al. (2005) have found a strong correlation between the calcium content and concentration of 2-heptanone in food products. It is possible that calcium and 2-heptanone interact with each other in the beverage and that the low evaluated freshness of the ‘Fruity fibre, FF’ is induced by the bitter and flat-tasting calcium. In general, the most liked beverage was ‘Light pineapple, LP’, which was fortified with magnesium and vitamin C, and had the highest intensity of freshness and a citrus-like odour. Magnesium has been shown to stimulate bitter sensations similar to calcium (Yang and Lawless, 2005), but in this case, the concentration used did not have a perceivable influence. However, the beverage products examined in study II were complex systems of several different ingredients, so fundamental comparisons between a single ingredient’s effects on flavour were not possible to define. Even then these findings underline the importance of studying the effects of nutritional fortification on sensory characteristics and liking in product development department.

The nutritional quality of food can also be improved by lowering the content of sugar or saturated fat. However, we found in study III that in general the sweetness intensity was an important indicator of the liking of drinking yoghurts. The most liked yoghurt among average consumers was the Czech raspberry-blueberry flavoured yoghurt, which had a high sweetness intensity. Previously, at least Barnes et al. (1991), Harper et al. (1991) and Johansen et al. (2009) have shown that a liking for yoghurts increases with increasing sweetness intensity. Perhaps less sweet yoghurts are generally experienced as less tasty.

Adult consumers have adjusted to the high sweetness intensity of yoghurt and, therefore, it might be difficult to consider the less sweet yoghurts as pleasant. For example, Tuorila et al. (1993) found that the preferred sucrose concentration, across a range of 6-12% tested, corresponded to the sucrose concentration of commercial yoghurts available in stores. The researchers attributed this finding partly to exposure, which has been proved to enhance liking. On the other hand, Johansen et al. (2009) recently showed that information about low-sugar content increased hedonic ratings among consumers, indicating that consumers are interested in low-sugar yoghurts. According to the National Findiet studies (Findiet 2007) and Roodenburg et al. (2008), Finns, like other Europeans, do not follow the recommended dietary guidelines, and for example, the consumption of sugar is within the upper limit. Roodenburg et al. (2008) stated that the responsibility of the food manufacturing industries is to improve the nutrient profile of food products. It is clear that manufacturers want to produce products that consumers will buy, but a wider availability of products with reduced sugar content together with promoting information on nutrition quality could increase the consumption of less sweet yoghurts among adults. However, manufacturers should keep in mind that many consumers may prefer sweetening with sucrose over sweeteners as Enneking et al. (2007) showed to be the case in beverages. Furthermore, the food industry could assess alternative methods to manufacture products with lower sugar content and take into account that the perception of sweetness can be modified with taste-odour and taste-texture interactions. For example, Djordjevic et al. (2004a; 2004b) and Saint-Eve et al. (2004) showed that adding a strawberry odour or decreasing the viscosity can increase the perceived sweetness intensity. There is a definite need to pursue more of this type of research to seek out alternative methods of improving nutritional quality without compromising on a pleasant taste.

Furthermore, children and adolescents should be considered as a special target group for improved diet quality, because food use in childhood has been shown to correlate with practices in adult life (Cooke, 2007; Unusan, 2006). Children are still in the process of developing their preferences through experiences and they can learn to prefer different tastes - even healthier ones. This implication is supported by our results in study V,

where we found that Finnish adolescents were positive toward rye bread and many of the young people mentioned it among their top ten favourite foods. This indicates that the adolescents have learned to prefer rye bread. To attain this kind of situation, we found that these adolescents were used to consuming rye bread regularly and they had limited home availability of refined bread, which was however, sometimes regarded as more of a delicacy. Similarly, Berg et al. (2003) and Neumark-Sztainer et al. (2003) found that home availability had a significant influence on children's food intake. In addition, Berg et al. (2000) found that students who consumed more high-fibre bread had a more positive view of high-fibre bread and thought it tasted better. In contrast to the adolescents in our study V and the Swedish adolescents in the study of Berg et al. (2000) who had a positive attitude toward healthful bread, Delk and Vickers (2007) found that increasing the content of whole-grain wheat in bread decreased the liking significantly among children in the USA who were not familiar with whole-grain products. Therefore it seems justifiable to suggest that home availability and repeated exposure to healthier food products can increase the liking and food choice of these products.

Overall, when the product information was made known to the participants, it enhanced the degree of liking for drinking yoghurts, wellness beverages as well as rye bread. This indicates that the brands had a generally positive image for the consumers, and when the product information was revealed and the samples were recognised as familiar they became more pleasant. This is in accordance with the results of Di Monaco et al. (2003) who found that revealing the brand names made the more familiar samples the ones that were preferred.

## **6.2 Relationships among sensory, non-sensory and consumer-related factors**

Another aim of this study was to investigate the consumer-related factors in relation to product variables in order to identify the degree of liking and interest in health food consumption in different consumer segments. First, however, the associations between consumer background variables are the subject of discussion. In study IV we showed that personal values, which are commonly believed to guide behaviour through attitudes and

motives, are connected with food choice motives. For example, the traditional participants underlined the motives "natural content", "familiarity" and "ethical concern", and were more concerned about their food and health compared with the hedonists. These motives are in accordance with traditional society-centred and conservative values, and are supported by similar findings of Brunsø et al. (2004). The finding that values can be the foundation for such food choice motives may have an impact on persuasion strategies. For example, different values can influence different behaviour, thus making it important for marketers to identify these connections. Furthermore, studies II, III and V supported previous research results that the importance of health-related attitudes as well as other food choice motives is associated with age and gender. We found that older subjects and females were significantly more concerned about their own health than younger subjects and males. This is in agreement with the results of Bower et al. (2003) and Kähkönen et al. (1996). Furthermore, we found in agreement with several studies (Holdago et al., 2000; Lindeman and Väänänen, 2000; Pollard et al., 1998; Steptoe et al., 1995) that females rated health and weight control as more important food choice motives than males. However, despite the higher health interest and concern, both the oldest consumer group and females considered sensory appeal to be the most important food choice motive. To sum up, our studies showed that people are individuals in their personal values and food choice motives, but several associations can be observed between different variables.

Elsewhere, numerous studies have segmented consumers based on their background variables and then connected consumer characteristics with preferences or food choice. For example, Tuorila et al. (1993) showed that men and females have different preferences for sweetness and sourness intensities in yoghurts; men increased hedonic scores for yoghurt with increasing sweetness intensity and decreased scores for increasing sourness intensity, whereas for the women there was no consistent relationship between sensory sweetness or sourness and hedonic responses. In study IV, we showed that personal values can be connected with the degree of liking for rye bread whereas traditional consumers evaluated the liking of all three types of rye bread slightly higher than the hedonistic participants. This may indicate that rye bread has a traditional image

and therefore the traditional consumers identify with it more. In comparison, the hedonistic participants preferred the rye bread with the most porous and least tough texture, which is in accordance with previous research, which showed that hedonists prefer a softer bread texture (Kihlberg et al., 2007). However, the association between traditional values and the degree of liking of rye bread may also derive from the significantly higher health concern of the traditional consumers, who may have, therefore, a more positive attitude towards healthy rye bread. Furthermore, we found that the adolescents who were more interested in their health consumed also more rye bread than adolescents who were less interested in eating a healthy diet. This is supported by a study of Wadolowska et al. (2008) who showed that consumers who were more interested in health consumed fruit, vegetables, and low-fat dairy products more often and had a greater preference for these products. Similarly, Roininen and Tuorila (1999) and Zandstra et al. (2001) have found that subjects rating high on the General health interest scale more often choose apples than chocolate bars, and have an increased consumption of vegetables and fruit and a lower intake of fat compared with subjects rating low on the General health interest scale. To sum up, our study confirmed associations found in earlier studies between personal values and/or attitudes and product characteristics. These associations could have several implications for product development and marketing. For example, healthy food advertising can benefit from using claims, which relate food cues to health among consumers interested in their health.

How about the consumers who are not particularly interested in health issues? In agreement with the studies of Glanz et al. (1998), Hearty et al. (2007), and Steptoe and Wardle (1999), we found that higher education was connected with a more positive attitude towards a healthy diet, whereas lower education and a younger age were connected with a higher importance given to price. Earlier studies about the effect of price on food choices (Epstein et al., 2006; French, 2003) suggest that reducing prices of healthful foods should be a part of public health strategy. In particular, this could influence the food choice behaviour of younger consumers and consumers with a lower socio-economic status, who have a poorer diet quality and do not consider health to be so important. In agreement with previous studies, the adolescents in study V reported that

they would be more interested in consuming rye bread as a snack during the school day if the price were equal to that of a chocolate bar. This finding supports considering food prices as a possible way to increase the healthy food consumption.

A rather new three-block L-shaped partial least squares regression (L-PLSR) method goes one step further and predicts the degree of liking from both consumer-related variables and sensory characteristics of the product simultaneously. We found the L-PLSR method as an effective and illustrative tool to use. The high variation between consumers in their hedonic responses and food choice motives can be clearly observed from Figure 7. This indicates that consumers are highly individual in their likings and motives, and manufacturing a food product according to the average hedonic response appeal to only a small segment of consumers. Much better market success for a food product can be achieved if both intrinsic and extrinsic characteristics of the product correspond with the preferences of clearly defined consumer segment. Here, we found that consumers who considered “health” and “natural content” to be important motives for their food choices and were more concerned about their health and had a higher education, considered sourness as a pleasant attribute for drinking yoghurts, wellness beverages as well as for rye breads, a flavour genuineness pleasant for the yoghurts, and astringency and berry-flavour pleasant for the wellness beverages. In contrast, the consumers who considered “convenience” and “price” as important food choice motives and were mainly under 27 years old found overall intensity as pleasant characteristics of all product types. In addition, these consumers considered the yoghurts with a sweeter taste and smoother texture, the wellness beverages with a more intense fruity flavour, and the rye breads with a more intensely rye and brown-like flavour to be more pleasant. This suggests that people who have a positive attitude toward health, natural ingredients and ethicality also like healthier food products, e.g. yoghurts and beverages that are less sweet and sourer to taste, because it supports their own motivations. This finding is in agreement with the study of Bower and Boyd (2003) that showed that subjects who were more concerned about their health evaluated lemon juices having lower sucrose concentrations as more ideal in sweetness level than unconcerned subjects. The tendency that the subjects concerned with health liked more of the healthier products, such as

wellness beverages, rye breads and less sweet drinking yoghurts, is in agreement with the assimilation theory (a.k.a. cognitive dissonance) (Deliza and MacFie, 1996). For example, in study II the beverages were advertised as wellness beverages already in the blind evaluation, which may have been a sufficient cue for the health-motivated participants to rate the degree of liking for wellness beverages significantly higher compared with the subjects unconcerned about health. In other words, the participants may have shifted their hedonic response for wellness beverages into a direction of more consistent with their health attitudes. A very sweet yoghurt taste, on the other hand, is in contrast with the motives of the health-motivated individual and the subject may evaluate the product less favourable than if he/she had no prior expectation of its healthiness. Our findings are supported, for example, a study of Lähteenmäki et al. (1997) who showed that consumers perceive juice with a lower sweetness and milk with a lower fat content more suitable for dieting than with a higher sweetness or fat content. Overall, our results suggest that the optimal product quality in terms of texture, taste and flavour, and nutrition information differ between individual consumers and indicate that each food product needs to be considered in relation to its specific market niche, and to which consumer segment will respond most positively to its sensory characteristics. All consumers do not find, for example, the sweeter yoghurt better. This should tell food manufacturers that at the present time, when health is a trend and healthier dietary habits are definitely demanded, the preferences for a certain consumer segment for healthier sensory characteristics of foods, such as lower sweetness intensity for yoghurts and higher sourness of wellness beverages, should be encouraged together with improved availability. Furthermore, Zandstra et al. (2001) demanded that for both product marketing and nutrition education it is important to segment consumers on the basis of their attitudes. This is consistent with earlier studies where information about healthiness has had a positive effect only on health-motivated consumers (Enneking et al., 2007; Ginon et al., 2009; Shepherd et al., 1991/2). Similarly, we showed that the product information given about yoghurts had different connotations for different age groups. Furthermore, nutrition education can be more effective if the message corresponds with the attitudes and motivations of a specific target group (Geeroms et al., 2008).

### **6.3 Methodological considerations**

This study contained several limitations. First, only a few model foods were used in this study. Apart from the flaxseed bakery products, all other samples were commercial food products. This introduces too many variables between the products to find out unambiguously what has the strongest influence on sensory quality. However, using commercial products is also an advantage; these products have been developed to meet consumer demands and are actually consumed by people in their everyday life. On the other hand, using commercial products brought another limitation to this study; within the same product category there were only a few products available. If the number of products tested had been higher, the results would have been more exploitable.

The number of consumers participating in hedonic tests was sufficient (in studies II-IV the total  $n = 162-224$ ). However, our findings cannot be generalized to the overall population. The population sample in our study was strongly biased to female subjects (percentage of females was between 78 and 85%) and to a younger age compared with the general Finnish population. The uneven distribution was a consequence of using a selection criterion that the participants should be responsible for their daily household purchases and use the product under study frequently. In addition, the uneven distribution derives from the fact that often women are more interested in participating in this kind of survey. Furthermore, the issue of context during the consumer tests was not considered. The quantitative consumer studies were conducted in a controlled environment in a central location, which does not correspond to a real consuming situation.

## 7 CONCLUSIONS

The results of this thesis provide new interdisciplinary understanding about the liking and choice of healthy food products by linking the theory and methods of food chemistry, sensory food science, health psychology and consumer behaviour research. It also uses a rather new multivariate data analysis method (L-PLS) to extract the relationships underlying the liking for a product, its sensory characteristics and consumer characteristics.

Firstly, the relationships between the intrinsic quality attributes of food were investigated, in terms of sensory characteristics and chemical-physical parameters. The result of this study demonstrates that the influences of enriching the nutritional quality of food products should be critically studied in order to achieve prolonged market success for the product. Secondly, this thesis examined the effects of sensory characteristics on liking. The average hedonic response correlated with the sweetness intensity of yoghurt, which suggests that adult consumers have adjusted to the high sweetness intensity of commercial yoghurt products. In addition, the adolescents familiar with the taste of rye bread had a positive attitude toward rye bread and showed this in their choices. This indicates that repeated exposure is an important promoter of liking for certain sensory characteristics. Thirdly, the results produced strong evidence that consumers are individual in their personal values, attitudes, and likings and how they evaluate the product-related non-sensory information. In addition, we showed that consumer-related factors can be connected to preferences for specific sensory characteristics of foods. It seems that there is a link between higher age, higher education, positive health attitude, health concern and perceiving the sensory characteristics connected to a healthier diet quality (less sweet, sourer and more genuine) as more pleasant. Based on this thesis it is advisable to take into account as many product- and consumer-related variables as possible in one study. Furthermore, this study suggests that the high variability between consumers should be taken into account when planning marketing communication and nutrition education in order to assure the most successful outcome.

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