

Consumer perception and acceptance of calorie-reduced dairy products

Forbrukeroppfatninger og –aksept av kalorireduisert meieriprodukter

Philosophiae Doctor (PhD) Thesis

Susanne Bølling Johansen

Dept. of Chemistry, Biology and Food Science
Norwegian University of Life Sciences

Ås 2010



Thesis number 2010: 03
ISSN 1503-1667
ISBN 978-82-575-0915-6

The fool doth think he is wise,
but the wise man knows himself to be a fool.

William Shakespeare (1564 - 1616)
“As You Like It”, Act 5, Scene 1

Consumer perception and acceptance of calorie-reduced dairy products

PhD Thesis 2010 © Susanne Bølling Johansen

ISBN-nr.: 978-82-575-0915-6

ISSN-nr.: 1503-1667

Printed by CopyCat avd. Ski, Jernbaneveien 2, 1400 Ski, Norway

Table of contents

Acknowledgements	v
Abstract.....	vii
Sammendrag (Norwegian abstract)	viii
List of papers	ix
Introduction	1
1 Background	1
2 Aims of the study	3
3 Theory and approach	5
3.1 <i>Factors affecting consumer response</i>	5
3.1.1 The stimulus.....	5
3.1.2 The consumer perception.....	9
3.1.2.1 Reference basis.....	10
3.1.2.2 Expectations	12
3.2 <i>Methodology</i>	13
3.2.1 Analytical methodology (trained assessors).....	13
3.2.1.1 Descriptive profiling.....	13
3.2.2 Affective methodology (consumers).....	14
3.2.2.1 Preference tests	14
3.2.2.2 Acceptance tests	15
3.2.3 Data analysis	16
4 Main results and discussion	19
5 Challenges and future perspectives	21
References.....	23
Abstracts of papers.....	31
Paper I-IV	

Acknowledgements

This thesis was written at Nofima Mat in Ås under the supervision of Adjunct Associate Professor Margrethe Hersleth (principal supervisor, Nofima Mat and UMB), Principal Research Scientist Tormod Næs (co-supervisor, Nofima Mat) and Professor Judith Narvhus (co-supervisor, UMB). The work was conducted in the period of 2005-2009 as part of a user managed innovation project financed by the Research Council of Norway through Grant number 167928/I10 and conducted in collaboration with TINE BA.

The motivation for this thesis is based on my interest in sensory science and the desire of studying and understanding the world of food. The thesis has given me the opportunity to develop my skills by including understanding of the final link in the chain of food consumption, thus the consumer. All papers in the thesis address important questions and problems, which have been raised as the work progressed and new discoveries were made, relating to different aspects in the understanding of consumption of calorie-reduced dairy products.

First of all, I wish to express my sincere gratitude to all of my supervisors Dr. Margrethe Hersleth, Dr. Tormod Næs and Dr. Judith Narvhus. My deepest thanks go to Dr. Margrethe Hersleth for her highly encouraging supervision, valuable advice and daily talks. Dr. Tormod Næs is especially thanked for his experienced supervision, helpful comments and always positive attitude and spirit.

My gratitude goes out to all my past and present colleagues. The people at the Sensory Science Group in Copenhagen who started my journey into Sensory Science, my fellow colleagues at “Toppetasjen” with whom I enjoyed many a happy moment and helpful scientific discussions, and my fellow Ph.D. students at Nofima Mat with whom I shared memorable social events. Dr. Øydis Ueland and Dr. Marit Rødbotten are especially thanked for their valuable comments. Thanks to Per Lea for answering my statistical questions. Thanks to Dr. Ulrike Böcker with whom I have had many discussions and joy about being a foreigner in Norway and to the “old lunch gang” Britt Signe Granli, Josefine Skaret, Asgeir Nikolai Nilsen and my office neighbour for years Dr. Oliver Tomic for making my work day even more fun.

Finally, I would like to thank my family and friends in Denmark for their care, support and understanding during long periods without visiting. In particular my mother and sister for their unconditional love and acceptance of my situation and its necessary sacrifices have given me peace of mind to finish the thesis. My gratitude also goes to my fiancé Jakob for letting me undertake this project, although it halfway into the completion meant living apart in different countries. Love and thanks from the bottom of my heart.

Ås, January 2010,
Susanne Bølling Johansen

Abstract

This thesis is a part of the research project “Low energy products and consumer preferences”, financed by the Research Council of Norway (NFR) through Grant 167928/I10. The thesis is based on three experiments. Consumers’ motivation for choice, and their healthiness perception of calorie-reduced dairy products, were examined in a cross-cultural study. Based on two experiments different consumer groups’ sensory acceptances were modelled, as well as the effect of providing additional nutritional information on these acceptances. The selected products throughout the project were calorie-reduced yoghurt and cheese. Results of all experiments and resulting articles are briefly stated below.

One experiment investigated young consumers’ motivation for choice, and their healthiness perception of calorie-reduced yoghurt and cheese. The experiment was performed as a cross-cultural study in three countries: Denmark, Norway and US. The main findings in this study may be summarised as follows:

- Overall, young consumers’ main motives for choosing calorie-reduced yoghurt and cheese were: low in fat content, keeps one healthy and tastes good.
- Generally, calorie-reduced yoghurt and cheese were perceived as relatively healthy compared to other foods.
- Minor cross-cultural differences were found in motives for choice and perceived healthiness of the products. However, the similarities between the countries were evident.

Two experiments investigated consumers’ sensory acceptances of calorie-reduced yoghurt and cheese, respectively and the effect of giving nutritional information about the tested product on these acceptances. The most important findings from these experiments are:

- The sensory properties were essential for acceptance of calorie-reduced yoghurt and low-fat cheese.
- A greater diversity in sensory acceptance among the consumers was observed for low-fat cheese than for calorie-reduced yoghurt.
- Sweetness had a major effect on acceptance of calorie-reduced yoghurt.
- Nutritional information was shown to influence acceptance, and the effect seemed to be dependent on type of product and the sensory attributes that were important for acceptance.
- Nutritional information generally increased acceptance of calorie-reduced yoghurt, while it decreased acceptance of low-fat cheese. Similar effects of information were not observed for the yoghurt and cheese with the highest hedonic ratings.

Sammendrag (Norwegian abstract)

Denne avhandlingen er en del av forskningsprosjektet ”Lavenergiprodukter med utgangspunkt i forbrukerpreferanser”, finansiert av Norges forskningsråd (NFR) gjennom 167928/I10. Avhandlingen er basert på tre forsøk. Forbrukeres motivasjon for valg og deres helseoppfatning av kalorireduerte meieriprodukter, ble undersøkt i en tverrkulturell studie. Basert på to eksperimenter ble ulike forbrukergruppers sensoriske aksept modellert, samt effekten av å gi ytterligere ernæringsinformasjon på denne aksepten. De utvalgte produktene i prosjektet var kalorireduert yoghurt og ost. Resultatene av alle eksperimenter og de derav følgende artiklene er kort angitt nedenfor.

Ett eksperiment undersøkte unge forbrukernes motivasjon for valg, og deres helseoppfatning av kalorireduert yoghurt og ost. Eksperimentet ble utført som en tverrkulturell studie i tre land: Danmark, Norge og USA. Hovedfunnene in denne studie kan oppsummeres som følger:

- Generelt var unge forbrukeres viktigste motiver for å velge kalorireduert yoghurt og ost: lavt fettinnhold, at det holder en sunn og smaker godt.
- Generelt ble kalorireduert yoghurt og ost oppfattet som relativt sunt i forhold til andre matvarer.
- Mindre tverrkulturelle forskjeller ble funnet i motiver for valg og helseoppfatningen av produktene. Imidlertid var det klare likheter mellom landene.

To eksperimenter undersøkte forbrukernes sensoriske aksept av henholdsvis kalorireduert yoghurt og ost, og effekten av å gi ernæringsinformasjon om de testede produktene på denne aksepten. De viktigste funnene fra disse eksperimentene er:

- De sensoriske egenskaper var avgjørende for aksept av kalorireduert yoghurt og lavfett ost.
- Et større mangfold i sensorisk aksept blant forbrukerne ble observert for lavfett ost enn for kalorireduert yoghurt.
- Søthet hadde en stor effekt på aksept av kalorireduert yoghurt.
- Ernæringsinformasjon ble vist å påvirke aksept, og effekten synes å være avhengig av type produkt og sensoriske egenskaper som var viktige for aksepten
- Generelt økte ernæringsinformasjonen aksepten av kalorireduert yoghurt, mens den reduserte aksepten av lavfett ost. Lignende effekter av informasjon ble ikke observert for yoghurten og osten med høyest hedonisk bedømmelse.

List of papers

- I. Johansen, S.B., Næs, T., and Hersleth, M. (2010). Motivation for choice and healthiness perception of calorie-reduced dairy products - a cross-cultural study. Accepted with revisions at *Appetite*.
- II. Johansen, S.B., Hersleth, M. and Næs, T. (2010). A new approach to product set selection and segmentation in preference mapping. *Food Quality and Preference*, 21(2), 188-196.
- III. Johansen, S.B., Næs, T., Øyaas, J. and Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21(1), 13-21.
- IV. Johansen, S.B., Hersleth, M., Narvhus, J., Øyaas, J. and Næs, T. (2010). Effects of information about fat percentage on acceptance of low-fat cheese. Manuscript.

Introduction

1 Background

Today widespread obesity is one of the biggest threats to public health. Up to 10% of society's health expenditures are related to obesity. In the last 10 to 15 years the number of overweight people in the Western world has risen by 30-40%, and the increase is larger among young people. The prevalence of overweight and obesity has also increased in Norway. Men have on average increased their weight by 9 kg since the beginning of the 1960s. At the same time, women and children have increased their weight by about 4 kg on average. In 2004 the incidence of type 2 diabetes had increased by 17% in only five years.

Norwegian nutrition authorities want to reduce the contribution of energy from fat in the diet from currently 34% to 30% of the total energy intake. Maximum 10% of that energy should come from saturated fat. Although the amount of milk fat was reduced by approximately 13000 tons in the period from 1980 to 2000, the milk fat still constitutes about 30% of total fat and 50% of saturated fat in the Norwegian diet. The authorities also recommend reducing the intake of added sugar. Added sugar provides only "empty calories", and a lot of added sugar displaces foods that are rich in vitamins and minerals. Apart from obesity, sugar also has a negative effect on other health related issues, such as dental health. "Comfort foods" such as soda, juice, sweets and cakes have become a part of everyday foods, and contributes over 70% of the sugar in the diet. The government recommends that the amount of added sugar in the diet should not account for more than 10% of the daily energy intake.

To achieve the goals recommended by the Norwegian authorities, it is a necessity that consumers are given the opportunity to choose healthier foods. For instance, when it comes to the selection of cheese variants consumers lack good options among the low-fat varieties. A broader range of calorie-reduced dairy products is desired. Milk products with added sugar contribute with a relatively small proportion of the total intake of added sugar. In Norway teenagers and adults consume less than 5% of added sugar from yogurt. Still, at the time this work was initiated great emphasis was placed on the high, and rising, sugar intake in children and adolescents from yoghurt, among other foods.

A growing proportion of the population is concerned about its health and thus the healthiness of foods. In Norway demands for products with less fat and sugar have been increasing for several years. Reduction of calorie intake is often an important strategy in consumers' attempt to prevent or reduce overweight and thus avoid the health risk factors and social stigmata associated with overweight and obesity. Most consumers want foods that are healthy but, at the same time, also tasty. They demand low-fat products and products with low sugar content

with an acceptable sensory quality, preferably similar to the traditional products. Unfortunately consumers often perceive these products as less palatable than the original versions with the higher fat and sugar content. The major challenge for the dairy industry is to produce calorie-reduced dairy products that are acceptable for a large number of consumers, both in terms of health and taste, and thus will survive in the market.

The present thesis was part of the user managed innovation project “Low energy products and consumer preferences”, financed by the Research Council of Norway and conducted in collaboration with the dairy product producer, TINE BA. Special attention was paid to cheese and yogurt and the effects of reducing fat and sugar content on consumer perception and acceptance of these products. These particular products were primarily selected because they represent an important part of the human intake of dairy products. In today’s food market with its strong focus on nutritional value of food and food-health relationships, calorie-reduced versions are in demand.

2 Aims of the study

The main aim of this work is to understand the sensory perception of calorie-reduced dairy products and its interaction with additional health information. A specific aim is to determine the critical factors in relation to specific consumer groups' acceptance of calorie-reduced dairy products. The selected products in the thesis were calorie-reduced yoghurt and cheese.

The aims of the studies on a general level were:

- Examining which motives are important for choosing calorie-reduced dairy products (paper I, III and IV).
- Examining how healthy consumers perceive calorie-reduced dairy products compared to other food products (paper I).
- Modelling consumer segments with different sensory acceptances (paper II, III and IV).
- Studying the interaction effect between sensory properties and information about nutritional content on consumers' hedonic ratings of calorie-reduced dairy products (paper III and IV).

3 Theory and approach

The purpose of this paragraph is to give a brief overview of the numerous factors affecting consumer perception and acceptance of calorie-reduced dairy products. A model based on models developed by Deliza and MacFie (1996), van Trijp and Schifferstein (1995) and Meilgaard, Civille, and Carr (1999) is shown in Figure 1. This model is used as the conceptual framework for the thesis, where each aspect of the figure contains several factors discussed in the following subsections. Other important factors such as packaging and branding exist, however these factors have not been investigated in the papers of the thesis. The figure illustrates that the consumer response (e.g. acceptance and choice) will depend on a number of factors related to the stimulus' intrinsic and extrinsic characteristics and the consumers' reference basis (e.g. socio-demographics, motivation, attitudes and experience) which will influence the expectations. Several studies have shown that the environment and consumption context affect the response of consumers (Hersleth, Mevik, Næs, & Guinard, 2003; Hersleth, Ueland, Allain, & Næs, 2005; Jaeger & Rose, 2008; Meiselman, Johnson, Reeve, & Crouch, 2000). Such factors have not been evaluated in the papers in this thesis and will therefore not be discussed further. Section 3.1 presents a more detailed description of factors affecting consumer response. Figure 2 shows the methodological framework of the thesis. For a more detailed description of the methodology see Section 3.2.

3.1 Factors affecting consumer response

The individual consumer's acceptance of a product takes place in a complex context and is dependent on a multitude of factors (Martens, 1999). A schematic model of some of the factors affecting consumers' response is shown in Figure 1.

3.1.1 The stimulus

As indicated in Figure 1, the consumer's responses will be affected by the type of food product (stimulus) tested, but also whether the test is conducted under blind or informed conditions. Naturally, under blind condition the perceptual focus is on the intrinsic characteristics of the stimulus. Humans have a preference for the sweet (Desor, Maller, & Turner, 1973; Steiner, 1974) and this probably explains the dominating effect of sweetness on consumer acceptance of food (Drewnowski, Nordensten, & Dwyer, 1998; Geiselman et al., 1998; Guinard, Zoumas-Morse, Mori, Panyam, & Kilara, 1996; Hayes & Duffy, 2008). Also fat seems to be important for consumer acceptance, as fat-reduced products often are perceived as less palatable by consumers than similar product types with a higher fat content (Brug & van Assema, 2001; Drewnowski & Specter, 2004). In the case of dairy products, calorie reduction is mainly achieved by reducing the fat content and in the case of yoghurt sometimes the sugar content as well.

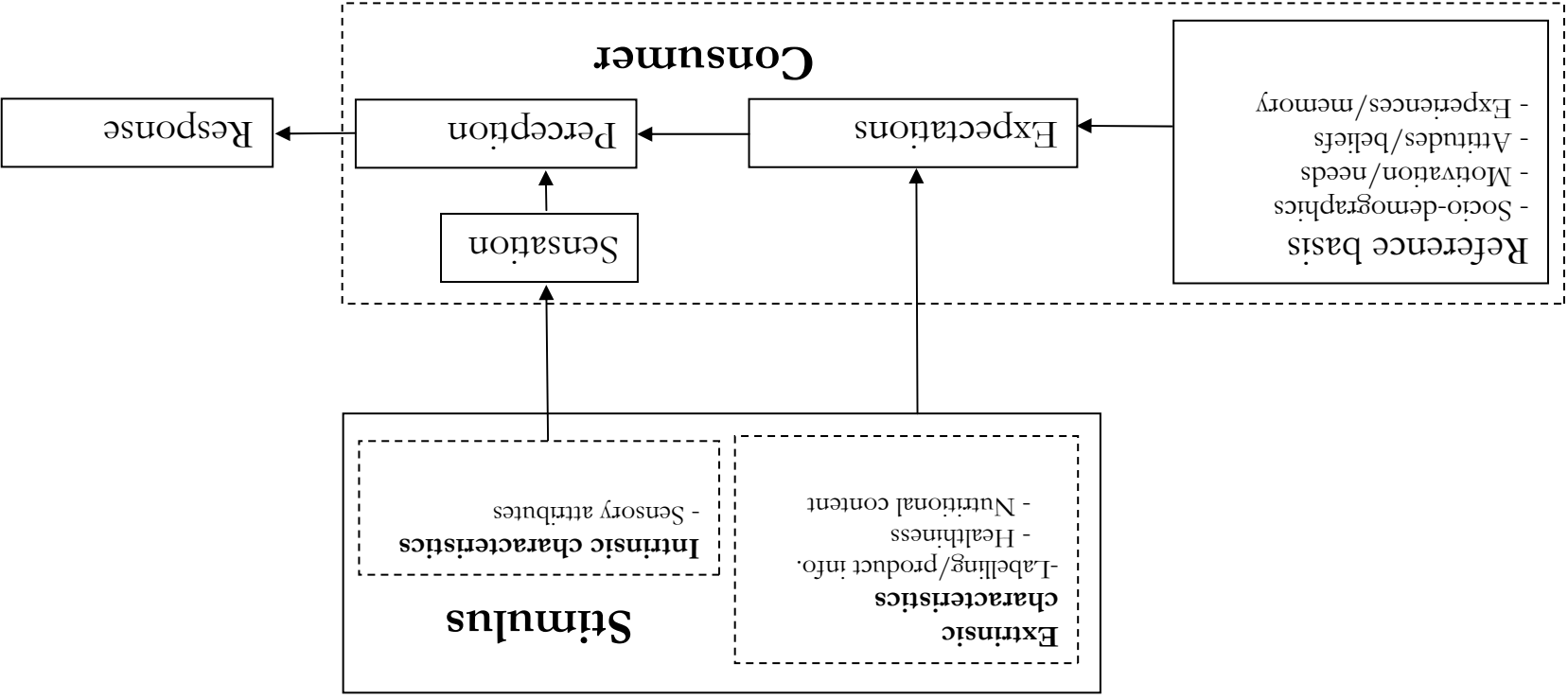


Figure 1. Schematic model of factors affecting consumers' response to calorie-reduced dairy products (see Section 3.1). The model is based on models developed by Deliza and MacFie (1996), van Trijp and Schifferstein (1995) and Meilgaard, Civille, and Carr (1999).

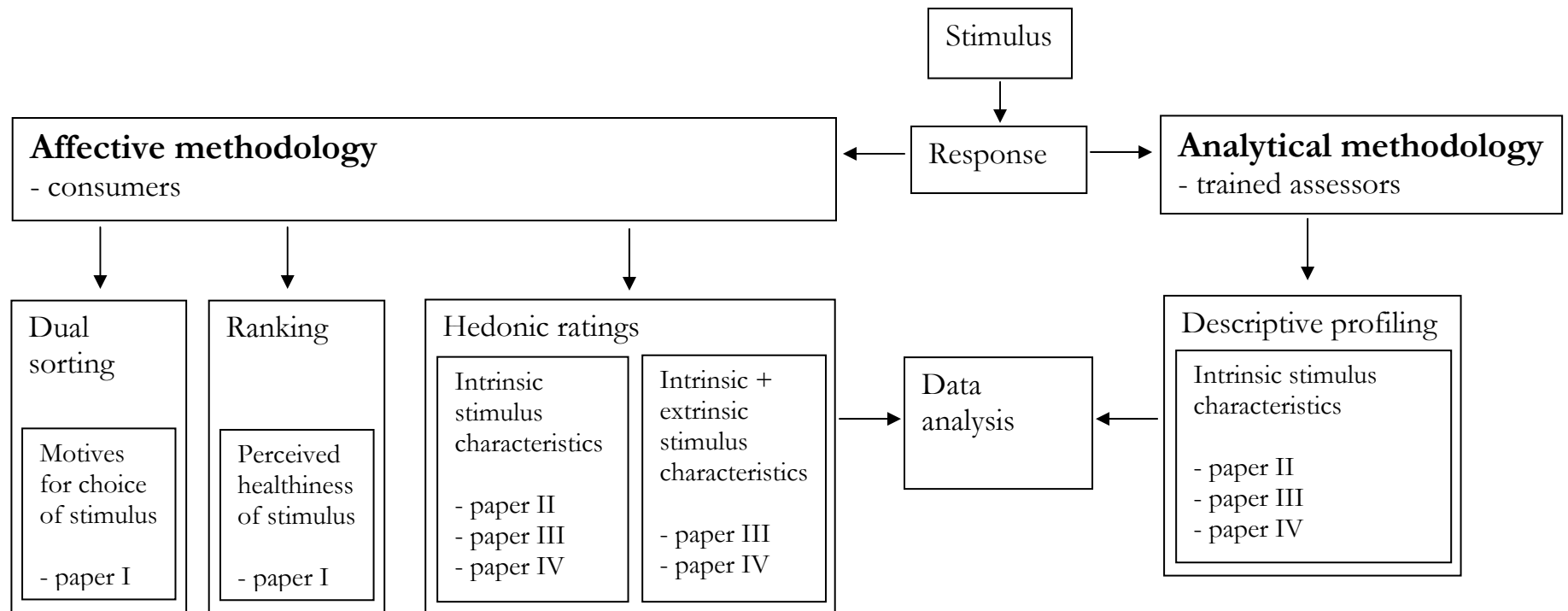


Figure 2. Methodological framework for the thesis (see Section 3.2.).

Acceptance studies have been conducted to study the importance of intrinsic properties like fattiness and sweetness in dairy products (Brennan, Setser, & Schmidt, 2002; Vickers, Holton, & Wang, 2001). For flavoured yoghurt the importance of consistency and sweetness for acceptance has been confirmed in several studies (Barnes, Harper, Bodyfelt, & McDaniel, 1991; Duboc & Mollet, 2001; Mojet & Köster, 2005; Tuorila, Somnardahl, Hyvönen, Leporanta, & Merimaa, 1993). The reason why low-fat yoghurts often are less liked by consumers than the full-fat versions (Hekmat & Reid, 2006) may be found in the influences of the fat reduction on the sensory profile. The problem of reducing the sucrose content in low-fat dairy products is not only minimizing its synergistic effect on the oral perception of fattiness (Drewnowski & Greenwood, 1983; Drewnowski, Shrager, Lipsky, Stellar, & Greenwood, 1989; Tuorila et al., 1993), but also reducing the sweetness. According to Vickers et al. (2001) it is the sweetness that is the main reason why consumers prefer yoghurts with high sugar content. Still, Tuorila et al. (1993) have found that consumers prefer a combination of sugar and fat corresponding to the commercial yoghurts available in stores, thus the yoghurts consumed regularly. For cheese, studies have shown that consumers, due to flavour and texture difference, find fat-reduced cheeses less acceptable than the full-fat versions (Childs & Drake, 2009; Whetstine, Drake, Nelson, & Barbano, 2006). Ritvanen et al. (2005) studied consumer acceptance of full fat (23-34%) and reduced fat (10-20%) cheeses. They found that cheeses appealing to consumers had a sticky consistency and a creamy, full, salty and acidic flavour.

Extrinsic attributes such as product information can affect consumer acceptance of food (Solheim, 1992). Research is therefore increasingly focusing on the effect of extrinsic information given on various product characteristics such as nutritional value (Ginon, Lohéac, Martin, Combris, & Issanchou, 2009; Visschers & Siegrist, 2009), animal welfare (Napolitano, Caporale, Carlucci, & Monteleone, 2007), functional properties (Ares, Giménez, & Gámbaro, 2009; Urala & Lähteenmäki, 2006), origin of raw materials (Caporale & Monteleone, 2001; Caporale, Policastro, Carlucci, & Monteleone, 2006; Schnettler, Vidal, Silva, Vallejos, & Sepúlveda, 2009; Stefani, Romano, & Cavicchi, 2006) and production process (Caporale & Monteleone, 2004; Iaccarino, Di Monaco, Mincione, Cavella, & Masi, 2006; Nielsen et al., 2009). For years the effect of health and nutritional information has received much attention in the literature (Helgesen, Solheim, & Næs, 1998; Kähkönen, Hakanpää, & Tuorila, 1999; Kähkönen & Tuorila, 1998; Kähkönen & Tuorila, 1999; Shepherd, Sparks, Bellier, & Raats, 1991/2; Solheim, 1992; Tuorila, Cardello, & Lesher, 1994; Westcombe & Wardle, 1997). However, these effects may depend on the type of food product tested (Wansink, 2003) and how familiar the consumers are with this product and its health improvements. Urala, Arvola, and Lahteenmaki (2003) found that the strength of information increased the perceived health benefits for less familiar health improving components.

For dairy products the effect of information about fat reduction has been studied thoroughly and various results have been found. An increase in hedonic ratings has been observed for spread and ice cream (Kähkönen, Tuorila, & Rita, 1996; Light, Heymann, & Holt, 1992; Aaron, Mela, & Evans, 1994), both positive and negative effects on acceptance have been seen for cheese (Light et al., 1992; Westcombe & Wardle, 1997), while no effect has been shown for yoghurt (Johansen, Næs, Øyaas, & Hersleth, 2010; Kähkönen, Tuorila, & Lawless, 1997; Westcombe & Wardle, 1997). However, when it comes to purchase intent of calorie-reduced yoghurt and cheese the sensory quality seems to have the primary effect while extrinsic attributes (price and information about fat content) may have only a secondary effect (Haddad et al., 2007; Solheim & Lawless, 1996). Studies on the effects of information about sugar reduction are limited. A study on soft drinks showed that sensory properties had the largest impact on product choice (Enneking, Neumann, & Henneberg, 2007). Calorie reduced labelling only increased the probability of choice if consumers had no product preference. A paper in the present thesis showed similar tendencies. Information about sugar reduction in calorie-reduced yoghurt may effect acceptance, however, sweetness had the largest impact on product acceptance (Johansen, Næs, Øyaas et al., 2010).

The variations in measured response observed in the studies mentioned may have been due to a number of factors not just related to type of foods tested. Specifically for the stimulus, differences in the type of information tested (e.g. nutritional content or health claims), whether tasting of a product was included, i.e. the sensory aspect was introduced, and whether the same product was tested with different information or different products were tested with different information, i.e. variations in the sensory profiles were introduced. In addition different consumer samples have been used (i.e. potential variations in consumer perception, see Section 2.1.2) and the type of response used to express perception was different (e.g. hedonic rating or purchase intent). These differences make it difficult to compare results. Still, it seems that the sensory quality influences consumer acceptance to a greater extent than nutritional information does.

3.1.2 The consumer perception

Due to numerous physical and psychological factors the consumers themselves are generating a major source for variations in the perception and measured response. A consumer's response to a stimulus may vary due to genetic differences in the sensitivity of the sense organs or differences in the mental treatment of the sensation. With previous experiences in memory, the brain interprets, organizes, and integrates the incoming sensation into perception (Meilgaard et al., 1999). Thus, perception is the act of becoming aware of a stimulus and its qualities based on the sensation that is caused and the interpretation of those sensations based on previous experience (Lawless & Heymann, 1999). Lastly, a response is formulated based on the individual consumer's perception (Schiffman, 1996). The following sections will look into

psychological factors related to consumers' reference basis and expectations. Still, it is important to mention that other important factors e.g. hunger and appetite, mood and emotions which are all likely to influence consumer perception and response.

3.1.2.1 Reference basis

The **socio-demographic** characteristics of the consumers are likely to influence the perception and response. These characteristics are e.g. gender, age, education, employment, income, geographic location, nationality, race, and religion. For calorie-reduced products, especially gender differences in the perception and response should be expected. Research has shown that females are more interested in health, nutritional content and taste aspects of foods than males (Ares, Giménez, & Gámbaro, 2008; Roininen, Lähteenmäki, & Tuorila, 1999). Women also tend to be more concerned about fat content and weight control (Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999; Steptoe, Pollard, & Wardle, 1995) and focus negatively on dietary fat in foods, whereas men considers the total nutritional content (Oakes & Slotterback, 2001a). Age effects may occur, as young adults seem to have biased healthiness expectations about foods (Oakes & Slotterback, 2001a) while older consumers may be more concerned for their health (Roininen et al., 1999). Education may be relevant as Gracia, Loureiro, & Nayga (2007) concluded that the well educated consumers more often read health related product information and thus generally makes healthy food choices. Nationality and geographical location may be relevant as research have shown a larger focus on nutrition in USA than in Europe (Bruhn et al., 1992; Musher-Eizenman, de Lauzon-Guillain, Holub, Leporc, & Charles, 2009).

The **motivation** for choice of food should be considered. Consumers may be motivated by e.g. an interest in health, weight concern, sensory pleasure, ideological reasons, convenience, price or familiarity (Crossley & Khan, 2001; Lindeman & Stark, 1999). However, food choice can also be a way of expressing one's personality and philosophy of life (Brunsø, Scholderer, & Grunert, 2004; Lindeman & Sirelius, 2001). Lindeman and Sirelius (2001) speculate that choosing food in a health- and weight-conscious manner can be an act of conforming to social norms and pressure, as weight control and health have come to represent virtue, success and status in the Western world. These days healthiness is becoming an increasingly important motive for food choice (Ares & Gámbaro, 2007; Prescott, Young, O'Neill, Yau, & Stevens, 2002), especially for older consumers (Honkanen & Frewer, 2009). For instance the healthiness and nutritional composition of yoghurt seems to be highly important motives for older consumers, while healthiness is less important for young consumers (Pohjanheimo & Sandell, 2009). The motivation of weight control also seems to be less important for young consumers (Pohjanheimo & Sandell, 2009; Sun, 2008). Generally sensory appeal seems to be an important motive for choice of

food (Honkanen & Frewer, 2009; Johansen, Næs, Øyaas et al., 2010; Prescott et al., 2002; Sun, 2008).

Attitudes and **beliefs** may influence consumers' perception and response. Acceptance and consumption of "healthier" foods are often based on beliefs and attitudes about anticipated positive consequences overruling barriers like cost or poor taste. These beliefs and attitudes are a result of several factors such as cultural background, eating habits established during childhood and the information about food obtained in daily life (Axelson, 1986; Lappalainen, Kearney, & Gibney, 1998; Sobal, 1998). Beliefs and attitudes about the healthiness of foods may diverge from fact (Oakes & Slotterback, 2001a, 2001b). To simplify choice people tend to classify foods according to a good/bad dichotomy (Rozin, Ashmore, & Markwith, 1996) and fat content is the most common category used for evaluation (Carels, Harper, & Konrad, 2006). This good/bad dichotomy may relate to sensory as well as health aspects. Foods perceived as healthy and leading to weight loss generally have a low fat content and are nutritious (e.g. contain vitamins, minerals and a good fat quality) (Carels et al., 2006; Carels, Konrad, & Harper, 2007; Roininen, Lähteenmäki, & Tuorila, 2000). On the other hand, foods high in calorie, fat or sugar content are generally perceived as unhealthy (Carels et al., 2006; Carels et al., 2007) but often also a source for pleasure. Roininen et al. (2000) found that for food to be considered pleasant it should have sensory appeal and good taste. The concepts of health and pleasure are often seen as opposites (Lindeman & Stark, 1999). Hamilton et al. (2000) made a distinction between health conscious and taste conscious consumers and discussed how this could influence their response to information on calorie reduction. Thus, beliefs and attitudes will strongly guide how information is perceived, and whether a product is accepted or rejected (Shepherd et al., 1991/2; Wilcock, Pun, Khanona, & Aung, 2004). A recent study found that when food is believed to be healthy, it is perceived as more appropriate to eat and as a result people tend to eat more of it (Provencher, Polivy, & Herman, 2009). For the dairy product category, yoghurt is believed to be a relatively healthy product (Kähkönen et al., 1997; Visschers & Siegrist, 2009), while the calorie-reduced types in addition are associated with slimming effects (Ares et al., 2008).

The **memory** of previous **experiences** with the stimulus in question or a similar stimulus will influence the sensory and hedonic perception as it generates expectations. Through experience an increased familiarity with a product is obtained and perhaps consumption of the stimulus even has turned into a habit. Studies on memory have shown that people are better at identifying novel stimuli than at recognising stimuli they have already experienced (Köster, Prescott, & Köster, 2004; Laureati et al., 2008; Mojet & Köster, 2002; Mojet & Köster, 2005; Möller & Hausner, 2006). In addition the novel stimuli are often less liked than the familiar ones (Ayabe-Kanamura et al., 1998; Sulmont-Rossé, Möller, Issanchou, & Köster, 2008; Sulmont, Issanchou, & Köster, 2002) Women may be better at remembering previously experienced stimuli compared to men (Laureati

et al., 2008; Mojet & Köster, 2002; Møller & Hausner, 2006), however, not all studies support this theory (Mojet & Köster, 2005; Møller, Mojet, & Köster, 2007). No age effects have been observed for incidental learning, only in case of intentional learning does the memory of young adults seem to be better than that of the elderly (Møller et al., 2007; Møller, Wulff, & Köster, 2004). The memory performance for different sensory characteristics seems to depend on the food product. For yoghurt, the texture memory of thickness seems to be good (Mojet & Köster, 2005) while the taste memory of sweetness does not (Köster et al., 2004). For custard desserts opposite results have been observed (Morin-Audebrand et al., 2009). Depending on the food product, people may overestimate the thickness of the remembered product (Mojet & Köster, 2005; Morin-Audebrand et al., 2009) while the sweetness may be underestimated (Köster et al., 2004) or overestimated (Morin-Audebrand et al., 2009; Møller et al., 2007). These shifts in memory for different sensory characteristics in previously experienced stimulus are likely to influence the expectations.

3.1.2.2 Expectations

Expectations influence product perception (Deliza & MacFie, 2001; Deliza & MacFie, 1996; Schifferstein, 2001), and thus consumer response (Cardello, 1995; Cardello & Sawyer, 1992). Two types of expectations can arise. Perceptual or analytical expectations when the stimulus is believed to possess certain sensory characteristics, and hedonic or affective expectations when the stimulus is believed to be liked or disliked to a certain degree. An important source of perceptual and hedonic expectations is previous experiences with the product or similar products from the same product category (Schifferstein, 2001; Tuorila, Meiselman, Cardello, & Leshner, 1998). External clues, such as visual information, play an important role in generating expectations within the consumer's judgmental frame of reference (Hutchings, 2003) and may lead to observed differences in consumer response even for foods already regarded as healthy, such as yoghurt (Schifferstein, Kole, & Mojet, 1999). If expectations are confirmed, or positively disconfirmed, it will result in increased consumer satisfaction. On the other hand, a negative disconfirmation will cause dissatisfaction and product rejection (Anderson, 1973; Deliza & MacFie, 1996). With repeated use, the degree of disconfirmation should diminish over time as consumers gain experience with a product, i.e. the expectations are modified. Therefore a large degree of disconfirmation is less likely to occur when a product is experienced the second time. Studies focusing on the effect of nutritional information on sensory expectations have shown that consumers view fat reduced foods as having inferior sensory properties as compared to full-fat products (Hamilton et al., 2000; Kähkönen & Tuorila, 1998; Tuorila et al., 1994). For instance calorie-reduced yoghurt is associated with sensory defects and inferior taste (Ares et al., 2008; Roininen et al., 2000) while full-fat yoghurt is associated with sensory appeal (Ares & Gámbaro, 2007; Ares et al., 2008). These expectations are most likely a result of previous experiences and are probably the reason that health information only

may affect first-time buyers, as product satisfaction is a key for repurchase in the long run (Grunert, 2003).

As reflected in this section many of the factors influencing consumer perception and thus response are more or less unconscious and intertwined, making it challenging to measure and evaluate the influence of each aspect. Still, it is certain that the consumer response to a stimulus such as calorie-reduced dairy products will be based on actual performance seen in the light of a combination of perceptual/hedonic expectations (does it taste good enough?) and established attitudes and beliefs (is it good for health?) about the product category.

3.2 Methodology

Consumer perception of the stimulus may be expressed by way of a measurable response. Several methods for measuring conscious perception exist. The influences of the unconscious and implicit factors are more difficult to measure. Still, methods for collecting consumers' reference basis (e.g. attitudes) have been developed (Pliner & Hobden, 1992; Roininen et al., 1999; van Strien, Frijters, Bergers, & Defares, 1986) and by means of multivariate models these types of consumer data may in combination with objective descriptive data be used to explain consumers' preference patterns (Pohjanheimo & Sandell, 2009; Westad, Hersleth, Lea, & Martens, 2003). The papers in the present thesis focus on quantitative methods. For that reason the quantitative methodology is highlighted in this section, even though qualitative studies also represent an important part of the literature. A schematic view of the methodology used in the thesis is shown in Figure 2.

3.2.1 Analytical methodology (trained assessors)

The two main types of analytical sensory analyses are discrimination testing and descriptive testing. Discrimination tests, also called difference tests, are the simplest of the sensory tests as they merely attempt to answer whether any perceivable difference exists between two products. The most well known discrimination methods are triangle tests and paired comparison tests (Lawless & Heymann, 1999; Meilgaard et al., 1999). Discrimination methods will not be discussed further, as they are not used in this thesis. In the following section descriptive sensory analyses will be described in more detail.

3.2.1.1 Descriptive profiling

The descriptive sensory technique allows for quantifying the perceived intensities of the sensory characteristics of products and thus answers how products differ from each other. Complete sensory description of products obtained from descriptive tests makes it possible to identify underlying ingredient and process variables, and/or sensory properties that are important for consumer acceptance.

Several methods exist, however, in the present thesis the descriptive method used was in accordance with Generic Descriptive Analysis described by Lawless and Heymann (1999).

Descriptive profiling is applied in paper II: Johansen, Hersleth, and Næs (2010), paper III: Johansen, Næs, Øyaas, and Hersleth (2010), and paper IV: Johansen, Hersleth, Narvhus, Øyaars, and Næs (2010). In paper II, descriptive analyses of cheeses are used as basis for selecting samples for consumer study and related to consumers hedonic ratings using modelling that allows for non-linear preference mapping. In paper III, descriptive analyses are used as basis for selecting yoghurts with high and/or low levels of sweet taste and rich texture which in a consumer study are tested blind and combined with information about sugar and fat content using a conjoint design. In paper IV, descriptive analyses of cheeses are used as basis for selecting samples for consumer study and related to consumers hedonic ratings tested under blind and informed conditions.

3.2.2 Affective methodology (consumers)

Affective evaluation attempts to quantify consumers' perception based on subjective response with regard to acceptance and/or preference. Two main approaches in quantitative consumer testing exist. In preference measurements, the consumer has a choice. One product has to be chosen over one or more products. In the measurement of acceptance, the consumer rates his or her liking for the product on a scale. Acceptance measurements can be done on single products and do not require a comparison to another product (Lawless & Heymann, 1999; Meilgaard et al., 1999). An important point is that a product may be preferred over another, although neither is liked. Alternatively a product may be less liked (because of its sensory profile) than another, but nevertheless preferred and purchased for other reasons e.g. price, health claims, packaging, etc. (Mela, 2000). The following section will give a short description of the preference and acceptance tests used in the thesis.

3.2.2.1 Preference tests

Ranking

Ranking is a simple way to compare multiple samples according to a single attribute, in the present case, healthiness is the attribute under consideration. Ranking is not identical to rating (Lawless & Heymann, 1999), as the data merely are ordinal, and no measure of degree of difference is involved. Consecutive samples which differ widely, as well as those which differ slightly will be separated by one rank unit (Meilgaard et al., 1999). With ranking the consumer are forced to distinguish between samples. The number of samples that can be ranked depends on the task. For visual inspection, many samples can be ranked, while for odour or flavour judgements at most five samples are recommended, depending on the circumstances (O'Mahony, 1986).

Ranking methodology is applied in paper I: Johansen, Næs, and Hersleth (2010), to study consumers healthiness perception of calorie-reduced yoghurt and cheese, which essentially is based on their knowledge and beliefs.

Dual sorting

The dual sorting technique is a stepwise approach that simplifies the procedure of indicating importance of a multiple number of items (Siret, 2004). At each step the number of items is reduced by half, as the least important items are removed, until the most important items remains.

Dual sorting is applied in paper I: Johansen, Næs, and Hersleth (2010), to study consumers motives for choosing calorie-reduced yoghurt and cheese.

3.2.2.2 Acceptance tests

Hedonic rating

A useful, sensitive, and well-established tool for measuring acceptability is the 9-point hedonic scale by Peryam and Pilgrim (1957). This numerical scale provides ratings of degree of liking or disliking of products, and can provide measures of the size of differences between products. Although preference refers to a choice among products, it can often be determined indirectly from acceptability ratings (Lawless & Heymann, 1999).

Conjoint analysis

Conjoint or trade-off analysis is a well known technique within marketing research for exploring the effects of and interactions between several product attributes on consumer acceptance (Green & Rao, 1971; Johnson, 1974). It is a technique that takes into account the fact that consumers make choices or trade-offs between independent, yet conjoint attributes in a product. Consumers are introduced to a number of product attributes and then asked to go through a series of trade-offs. Quantitative data are generated, which can be subjected to statistical analyses. The end-product is determination of which product attribute(s) are the most important to the consumers (Drake, 2009).

Hedonic ratings are applied in paper II: Johansen, Hersleth, and Næs (2010), paper III: Johansen, Næs, Øyaas, and Hersleth (2010), and paper IV: Johansen, Hersleth, Narvhus, Øyaars, and Næs (2010). In paper II, non-linear preference mapping on hedonic ratings from consumers testing in blind condition are modelled. In papers III and IV, hedonic ratings from consumers testing in blind and informed conditions are studied. The difference between these studies lies in the informed condition. The effect of true information on acceptance of low-fat cheese was studied in paper IV, while a conjoint design was applied in paper III to study the effects of specific sensory attributes combined with nutritional information on acceptance of calorie-reduced yoghurt.

3.2.3 Data analysis

Application of experimental design and data modelling is essential in studying the importance of intrinsic and extrinsic factors and relationships between them. Even relations between the consumers' responses and their reference basis may be modelled.

Analysis of variance (ANOVA) is a collection of statistical methods that is based on comparing two variance estimates with each other (Lea, Næs, & Rødbotten, 1997). ANOVA may be used on descriptive sensory data with the assumptions that the data represents a continuous distribution on a linear scale and that each assessor measures the samples in the same way. Although this may not be entirely true for sensory data, the applied methods of analysis are robust to moderate violations of these assumptions (Næs & Langsrud, 1998). Contrary to data obtained from a sensory panel, consumer data are often more "noisy" as the consumers have not been trained and their ratings are seldom replicated. Thus, results from ANOVA of consumer data should be treated with care and supported by multivariate analysis as well as inspection of the raw data.

Numerous multivariate data analysis techniques exist (Martens & Martens, 2001; Næs & Risvik, 1996). Principal Component Analysis (PCA) is a simple method used to study systematic variations in a multivariate data set. In PCA the complete set of variables can be reduced to a smaller number of principal components retaining the maximum amount of systematic information expressed by percentage of explained variance. Often an extension to studying relationships between different types of data sets is more relevant. Preference mapping is a method that relates descriptive sensory data to consumer acceptance data using statistical regression methods such as Principal Component Regression (PCR) or Partial Least Squares Regression (PLSR) and then presenting the results graphically in maps. Thus, regression methods find the relationships between the X-matrix (predictor variables) and the Y-matrix (dependent variables). PCR is a two-steps procedure. First a PCA transforms X into T followed by regression of Y on T. In PLSR the modelling of X and Y is done simultaneously which ensures Y-relevant principal components from X. The idea behind the models is to find linear combinations of X which are stable and at the same time are able to predict Y in a valid way. A major issue when using these methods, in particular for non-linear ideal points models (McEwan, 1996), is the statistical need for as many tested products as possible to obtain precise model estimates. Thus, the practical limitation related to the number of products a consumer should test (to minimize fatigue and tediousness) makes it difficult to apply non-linear models. A possible solution could be to analyse all consumers with the same model and thereby only focus on the average acceptance. However, this is generally not recommended. A more useful approach is to apply segmentation. It represents a type of compromise between individual and joint modelling, while at the same time providing information on possible segments of consumers with similar preference patterns in the data sets. For segmentation purposes a number of techniques exist

based on various types of cluster analysis, e.g. fuzzy clustering (Wedel & Kamakura, 1998; Wedel & Steenkamp, 1989, 1991).

The data analyses in the thesis are mainly performed by analysis of variance (ANOVA) and multivariate analysis (PCA, PCR and PLSR). ANOVA was applied in papers II, III and IV while multivariate analysis was applied in all four papers. In paper I additional statistical methods are applied (chi-square analysis, nominal logistic regression and the Friedman test). Paper II presents an approach to product set selection and consumer segmentation within non-linear preference mapping. A conjoint design is used in paper III and ANOVA is applied to study the importance of the intrinsic and extrinsic factors as well as their interactions.

4 Main results and discussion

The main contribution of the thesis has been to demonstrate that consumers generally perceive calorie-reduced yoghurt and cheese to be relatively healthy. Acceptance and choice of these healthier alternatives are not merely governed by information about health improvements. Sensory acceptance was confirmed to be an important factor, and through modelling, consumer segments with different sensory preferences were revealed. This contribution is established through the different papers in the thesis, and may be divided into the following four items.

Achieved increased understanding about young consumers' motivations for choice and healthiness perceptions of calorie-reduced yoghurt and cheese.

In paper I, a cross-cultural study was conducted in California, Denmark and Norway. It was shown that young consumers regardless of culture have very similar motives for choosing calorie-reduced yoghurt and cheese. The three motives which received the highest priority across countries were related to low fat content, healthiness and good taste. Moreover, weight control, nutritional aspects, availability and lifestyle seemed to be important motivators. Another interesting observation was that young consumers generally seem to perceive calorie-reduced yoghurt and cheese as relatively healthy. All three countries ranked calorie-reduced yoghurt as healthier than calorie-reduced cheese, although, only a significant difference in perceived healthiness was observed for the Californian respondents. Calorie-reduced yoghurt was ranked among the healthiest products by the respondents from California and Denmark. In Norway calorie-reduced yoghurt was ranked as significantly less healthy than salmon, which was ranked as the healthiest product in all three countries. This result may be explained by the Norwegian media's focus on sugar content of yoghurt (including calorie-reduced) previous to the study.

Point out a new approach for non-linear preference mapping and consumer segmentation in modelling of consumers testing of different products.

Paper II demonstrated a new approach to product set selection and segmentation in preference mapping. In particular, the approach was tested for ideal point models. The selection method allowed for different products to be tested by different consumers. Fuzzy clustering with the use of residual distance was shown to be a useful tool for the segmentation of consumers in preference mapping. An advantage of this method is that the number of products served are kept low (reducing the cost of the study and minimizing the risk of fatigue, adaptation and satiety), while the ability to model the preferences of different consumer segments is preserved. The approach was evaluated using a case study on low-fat cheese. The case study focused on two principal components, however, the method can

also be used in situations with more principal components in the model. Since residuals are used as criterion in fuzzy clustering, the procedure easily handles the different sets of products served to the different consumer groups. Three different preference patterns for low-fat cheese were characterized in the case study. The method proved stable with respect to the cluster solutions found, and no convergence problems were detected.

Point out the potential of using conjoint analysis to study consumers' trade-offs with respect to specifically related intrinsic and extrinsic product characteristics.

The study in paper III showed that conjoint methodology is an appropriate tool to investigate the effects of specific intrinsic attributes interacting with related extrinsic product features. A new approach is proposed for the design of studies, based on selecting samples from a PCA plot of sensory data. The advantages of this method are that emphasis is given to sensory properties instead of specific products and that it is relatively simple to set up the design and to analyse effects of sensory and extrinsic attributes.

Achieved increased understanding about the effect of the sensory characteristics and nutritional information on consumer acceptance of calorie-reduced yoghurt and cheese.

Papers III and IV investigated the effect of sensory attributes and nutritional information on acceptance of calorie-reduced yoghurt (paper III) and cheese (paper IV). Both studies established that the sensory aspect is critical for product acceptance. Paper III confirmed the importance of sensory properties, especially sweetness, for consumers' acceptance of calorie-reduced yoghurt. Results showed that information about sugar content affect acceptance and that this effect was independent of the strength of the sensory attributes. The cheese study (paper IV) illustrated individual differences among the consumers with regard to sensory acceptance. Still, the majority preferred cheeses with acidic flavour and cream flavour and a fatty and sticky consistency. The study found consumer segments that reacted differently to the information about fat content. The results from informed condition showed a tendency to be dependent on the sensory properties of the cheeses. An interesting observation when comparing the two studies is the differences in the effect of giving nutritional information. In paper III (yoghurt) the information generally had a positive effect on consumers' hedonic rating, except for the product with the highest sensory acceptance. In paper IV (cheese) an opposite result was observed as the information generally had a negative effect on consumers' hedonic rating, except for the product with the highest sensory acceptance.

5 Challenges and future perspectives

Measuring consumer perception and acceptance in an appropriate manner is a continuous challenge within the sensory community. For many years preference mapping has been a favoured method of analysis, as it efficiently combines descriptive sensory data (objective) with consumer hedonic ratings (subjective). Thus, traditionally the method only focuses on the sensory aspects of consumer acceptance of foods. Today, more and more product information is available for consumers to take into account with respect to packaging, price, healthiness, origin of raw material, animal well-fair, organic production, fair-trade etc. The need for extending the traditional focus on sensory quality to include other aspects of food liking and preference is therefore highly relevant. Especially regarding healthy and unhealthy consumption behaviour, where consumers trade off the drawbacks and benefits inherent in food acceptance and choice.

The conjoint methodology is an efficient tool for exploring consumer acceptance and trade-offs between several product attributes. Testing of sensory aspects with extrinsic product characteristics (additional value) in a conjoint design may increase the understanding of consumer acceptance. A challenge with this approach is to include tasting of products, as this limits the number of “conjoint samples” each consumer can assess. A possible solution may be to let the consumer taste a few samples with distinctively different sensory profiles under blind condition and afterwards letting the consumers evaluate additional extrinsic attributes based on their memory of the samples. This approach will allow for a larger number of extrinsic attributes to be tested, as it is less demanding and fatiguing.

Different types of software are increasingly becoming important in sensory and consumer research. Not just with respect to data analysis but also for obtaining data. These tools make it easy to obtain an increased number of different consumer data. Thus, a major challenge is to analyse and interpret this increased amount of data in a simple and fast manner. Consumers are not homogenous, it is therefore necessary to include consumer segmentation as part of the interpretation. At present consumer segmentation is often based on differences in socio-demographics or attitudes. A questionnaire dividing consumers in terms of life stages may prove useful. For example, it is likely that a single mother of 17, in many cases have more in common with a single mother of 35 than with other teenage girls.

In the present thesis the application of specific attitude scales (e.g. Health and Taste Attitude Scale) to segment consumers was less appropriate. Likely reasons may be that the recruitment requirements regarding health consciousness resulted in respondents with similar attitudes or that the applied attitude scales were outdated or perhaps not useful for Norwegian consumers. This should be further investigated.

At the 8th Pangborn Sensory Science Symposium in Florence, Italy in 2009, one of the workshops highlighted the theme of emotions. This is a topic of growing interest within the sensory community, as it brings another dimension into consumer perception and response and may show to be helpful in improving the validity of the models on consumer acceptance and behaviour. In addition, a recent paper by Köster (2009) stresses the need to address the unconscious aspects of consumer behaviour in order for the field of sensory consumer science to improve its understanding. To study these unconscious aspects Köster points out that the field needs to conduct more interdisciplinary research, have more insight into, and application of psychology, and in general apply more deductive approaches in the research.

The eating experience as a whole takes place in a complex context, depending on factors related to the individual, the product and the consumption situation (Martens, 1999). Knowledge regarding more aspects is necessary to increase our understanding and the predictive validity of the models on consumer acceptance and behaviour in the food choice situation.

References

- Anderson, R. E. (1973). Consumer Dissatisfaction: The Effect of Disconfirmed Expectancy on Perceived Product Performance. *Journal of Marketing Research*, 10(1), 38-44.
- Ares, G., & Gámbaro, A. (2007). Influence of gender, age and motives underlying food choice on perceived healthiness and willingness to try functional foods. *Appetite*, 49(1), 148-158.
- Ares, G., Giménez, A., & Gámbaro, A. (2008). Understanding consumers' perception of conventional and functional yogurts using word association and hard laddering. *Food Quality and Preference*, 19(7), 636-643.
- Ares, G., Giménez, A., & Gámbaro, A. (2009). Consumer perceived healthiness and willingness to try functional milk desserts. Influence of ingredient, ingredient name and health claim. *Food Quality and Preference*, 20(1), 50-56.
- Axelsson, M. L. (1986). The impact of culture on food-related behavior. *Annual Review of Nutrition*, 6, 345-363.
- Ayabe-Kanamura, S., Schicker, I., Laska, M., Hudson, R., Distel, H., Kobayakawa, T., & Saito, S. (1998). Differences in Perception of Everyday Odors: a Japanese-German Cross-cultural Study. *Chemical Senses*, 23(1), 31-38.
- Barnes, D. L., Harper, S. J., Bodyfelt, P. W., & McDaniel, M. R. (1991). Prediction of Consumer Acceptability of Yogurt by Sensory and Analytical Measures of Sweetness and Sourness. *Journal of Dairy Science*, 74(11), 3746-3754.
- Brennan, E. M., Setser, C., & Schmidt, K. A. (2002). Yogurt Thickness: Effects on Flavor Perception and Liking. *Journal of Food Science*, 67(7), 2785-2789.
- Brug, J., & van Assema, P. (2001). Beliefs About Fat. Why do we Hold Beliefs About Fat and why and how do we Study these Beliefs? In L. J. Frewer, E. Risvik, & H. Schifferstein (Eds.), *Food, People and Society: A European Perspective of Consumers' Food Choices*. Berlin, DE: Springer-Verlag, Chap. 3, pp. 39-54.
- Bruhn, C. M., Cotter, A., Diaz-Knauf, K., Sutherlin, J., West, E., Wightman, N., Williamson, E., & Yaffee, M. (1992). Consumer Attitudes and Market Potential for Dairy Products Utilizing Fat Substitutes. *Journal of Dairy Science*, 75(9), 2569-2577.
- Brunso, K., Scholderer, J., & Grunert, K. G. (2004). Closing the gap between values and behavior - a means-end theory of lifestyle. *Journal of Business Research*, 57(6), 665-670.
- Caporale, G., & Monteleone, E. (2001). Effect of expectations induced by information on origin and its guarantee on the acceptability of a traditional food: olive oil. *Sciences Des Aliments*, 21(3), 243-254.
- Caporale, G., & Monteleone, E. (2004). Influence of information about manufacturing process on beer acceptability. *Food Quality and Preference*, 15(3), 271-278.
- Caporale, G., Policastro, S., Carlucci, A., & Monteleone, E. (2006). Consumer expectations for sensory properties in virgin olive oils. *Food Quality and Preference*, 17(1-2), 116-125.

- Cardello, A. V. (1995). Food quality: relativity, context and consumer expectations. *Food Quality and Preference*, 6(3), 163-170.
- Cardello, A. V., & Sawyer, F. M. (1992). Effects of disconfirmed consumer expectations on food acceptability. *Journal of Sensory Studies*, 7(4), 253-277.
- Carels, R. A., Harper, J., & Konrad, K. (2006). Qualitative perceptions and caloric estimations of healthy and unhealthy foods by behavioral weight loss participants. *Appetite*, 46(2), 199-206.
- Carels, R. A., Konrad, K., & Harper, J. (2007). Individual differences in food perceptions and calorie estimation: An examination of dieting status, weight, and gender. *Appetite*, 49(2), 450-458.
- Childs, J. L., & Drake, M. (2009). Consumer perception of fat reduction in cheese. *Journal of Sensory Studies*, 24(6), 902-921.
- Crossley, M. L., & Khan, S. N. (2001). Motives underlying food choice: dentists, porters and dietary health promotion. *British Dental Journal*, 191(4), 198-202.
- Deliza, R., & MacFie, H. (2001). Product Packaging and Branding. In L. J. Frewer, E. Risvik, & H. Schifferstein (Eds.), *Food, People and Society: A European Perspective of Consumers' Food Choices*. Berlin, DE: Springer-Verlag, Chap. 4, pp. 55-72.
- Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: a review. *Journal of Sensory Studies*, 11(2), 103-128.
- Desor, J. A., Maller, O., & Turner, R. E. (1973). Taste in acceptance of sugars by human infants. *Journal of Comparative and Physiological Psychology*, 84(3), 496-501.
- Drake, M. A. (2009). Modern Sensory Practices. In S. Clark, M. Costello, M. Drake, & F. Bodyfelt (Eds.), *The Sensory Evaluation of Dairy Products* (2nd ed.). New York, NY: Springer Science+Business Media, Chap. 17, pp. 505-530.
- Drewnowski, A., & Greenwood, M. R. C. (1983). Cream and Sugar: Human Preferences for High-Fat Foods. *Physiology & Behavior*, 30(4), 629-633.
- Drewnowski, A., Nordensten, K., & Dwyer, J. (1998). Replacing sugar and fat in cookies: impact on product quality and preference. *Food Quality and Preference*, 9(1-2), 13-20.
- Drewnowski, A., Shrager, E. E., Lipsky, C., Stellar, E., & Greenwood, M. R. C. (1989). Sugar and Fat: Sensory and Hedonic Evaluation of Liquid and Solid Foods. *Physiology & Behavior*, 45(1), 177-183.
- Drewnowski, A., & Specter, S. E. (2004). Poverty and obesity: the role of energy density and energy costs. *American Journal of Clinical Nutrition*, 79(1), 6-16.
- Duboc, P., & Mollet, B. (2001). Applications of exopolysaccharides in the dairy industry. *International Dairy Journal*, 11(9), 759-768.
- Enneking, U., Neumann, C., & Henneberg, S. (2007). How important intrinsic and extrinsic product attributes affect purchase decision. *Food Quality and Preference*, 18(1), 133-138.
- Geiselman, P. J., Smith, C. F., Williamson, D. A., Champagne, C. M., Bray, G. A., & Ryan, D. H. (1998). Perception of Sweetness Intensity Determines

- Women's Hedonic and other Perceptual Responsiveness to Chocolate Food. *Appetite*, 31(1), 37-48.
- Ginon, E., Lohéac, Y., Martin, C., Combris, P., & Issanchou, S. (2009). Effect of fibre information on consumer willingness to pay for French baguettes. *Food Quality and Preference*, 20(5), 343-352.
- Gracia, A., Loureiro, M., & Nayga Jr., R. M. (2007). Do consumers perceive benefits from the implementation of a EU mandatory nutritional labelling program? *Food Policy*, 32(2), 160-174.
- Green, P. E., & Rao, V. R. (1971). Conjoint Measurement for Quantifying Judgmental Data. *Journal of Marketing Research*, 8(3), 355-363.
- Grunert, K. G. (2003). Purchase and consumption: the interdisciplinary nature of analysing food choice. *Food Quality and Preference*, 14(1), 39-40.
- Guinard, J.-X., Zoumas-Morse, C., Mori, L., Panyam, D., & Kilara, A. (1996). Effect of Sugar and Fat on the Acceptability of Vanilla Ice Cream. *Journal of Dairy Science*, 79 (11), 1922-1927.
- Haddad, Y., Haddad, J., Olabi, A., Shuayto, N., Haddad, T., & Toufeili, I. (2007). Mapping determinants of purchase intent of concentrated yogurt (Labneh) by conjoint analysis. *Food Quality and Preference*, 18(5), 795-802.
- Hamilton, J., Knox, B., Hill, D., & Parr, H. (2000). Reduced fat products – Consumer perceptions and preferences. *British Food Journal*, 102(7), 494-506.
- Hayes, J. E., & Duffy, V. B. (2008). Oral sensory phenotype identifies level of sugar and fat required for maximal liking. *Physiology & Behavior*, 95(1-2), 77-87.
- Hekmat, S., & Reid, G. (2006). Sensory properties of probiotic yogurt is comparable to standard yogurt. *Nutrition Research*, 26(4), 163-166.
- Helgesen, H., Solheim, R., & Næs, T. (1998). Consumer purchase probability of dry fermented lamb sausages. *Food Quality and Preference*, 9(5), 295-301.
- Hersleth, M., Mevik, B.-H., Næs, T., & Guinard, J.-X. (2003). Effect of contextual factors on liking for wine - use of robust design methodology. *Food Quality and Preference*, 14(7), 615-622.
- Hersleth, M., Ueland, Ø., Allain, H., & Næs, T. (2005). Consumer acceptance of cheese, influence of different testing conditions. *Food Quality and Preference*, 16(2), 103-110.
- Honkanen, P., & Frewer, L. (2009). Russian consumers' motives for food choice. *Appetite*, 52(2), 363-371.
- Hutchings, J. B. (2003). *Expectations and the Food Industry - The Impact of Color and Appearance*. New York, NY: Kluwer Academic/Plenum Publishers.
- Iaccarino, T., Di Monaco, R., Mincione, A., Cavella, S., & Masi, P. (2006). Influence of information on origin and technology on the consumer response: The case of *soppressata* salami. *Food Quality and Preference*, 17(1-2), 76-84.
- Jaeger, S. R., & Rose, J. M. (2008). Stated choice experimentation, contextual influences and food choice: A case study. *Food Quality and Preference*, 19(6), 539-564.

- Johansen, S. B., Hersleth, M., Narvhus, J., Øyaas, J., & Næs, T. (2010). Effects of information about fat percentage on acceptance of low-fat cheese. *Unpublished manuscript*.
- Johansen, S. B., Hersleth, M., & Næs, T. (2010). A new approach to product set selection and segmentation in preference mapping *Food Quality and Preference*, 21(2), 188-196.
- Johansen, S. B., Næs, T., & Hersleth, M. (2010). Motivation for choice and healthiness perception of calorie-reduced dairy products - a cross-cultural study. *Submitted to Appetite*.
- Johansen, S. B., Næs, T., Øyaas, J., & Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21(1), 13-21.
- Johnson, R. M. (1974). Trade-Off Analysis of Consumer Values. *Journal of Marketing Research*, 11(2), 121-127.
- Kähkönen, P., Hakanpää, P., & Tuorila, H. (1999). The effect of information related to fat content and taste on consumer responses to a reduced-fat frankfurter and a reduced-fat chocolate bar. *Journal of Sensory Studies*, 14(1), 35-46.
- Kähkönen, P., & Tuorila, H. (1998). Effect of Reduced-fat Information on Expected and Actual Hedonic and Sensory Ratings of Sausage. *Appetite*, 30(1), 13-23.
- Kähkönen, P., & Tuorila, H. (1999). Consumer responses to reduced and regular fat content in different products: effects of gender, involvement and health concern. *Food Quality and Preference*, 10(2), 83-91.
- Kähkönen, P., Tuorila, H., & Lawless, H. (1997). Lack of effect of taste and nutrition claims on sensory and hedonic responses to a fat-free yoghurt. *Food Quality and Preference*, 8(2), 125-130.
- Kähkönen, P., Tuorila, H., & Rita, H. (1996). How information enhances acceptability of a low-fat spread. *Food Quality and Preference*, 7(2), 87-94.
- Köster, E. P. (2009). Diversity in the determinants of food choice: A psychological perspective. *Food Quality and Preference*, 20(2), 70-82.
- Köster, M. A., Prescott, J., & Köster, E. P. (2004). Incidental learning and memory for three basic tastes in food. *Chemical Senses*, 29(5), 441-453.
- Lappalainen, R., Kearney, J., & Gibney, M. (1998). A pan EU survey of consumer attitudes to food, nutrition and health: an overview. *Food Quality and Preference*, 9(6), 467-478.
- Laureati, M., Morin-Audebrand, L., Pagliarini, E., Sulmont-Rossé, C., Köster, E. P., & Mojet, J. (2008). Food memory and its relation with age and liking: An incidental learning experiment with children, young and elderly people. *Appetite*, 51(2), 273-282.
- Lawless, H., & Heymann, H. (1999). *Sensory Evaluation of Food: Principles and Practices*. New York, NY: Kluwer Academic/Plenum Publishers.
- Lea, P., Næs, T., & Rødbotten, M. (1997). *Analysis of Variance for Sensory Data*. Chichester, UK: John Wiley & Sons.
- Light, A., Heymann, H., & Holt, D. L. (1992). Hedonic Responses to Dairy-Products: Effects of Fat Levels, Label Information, and Risk Perception. *Food Technology*, 46(7), 54-57.

- Lindeman, M., & Sirelius, M. (2001). Food choice ideologies: the modern manifestations of normative and humanist views of the world. *Appetite*, 37(3), 175-184.
- Lindeman, M., & Stark, K. (1999). Pleasure, Pursuit of Health or Negotiation of Identity? Personality Correlates of Food Choice Motives Among Young and Middle-aged Women. *Appetite*, 33(1), 141-161.
- Martens, H., & Martens, M. (2001). *Multivariate Analysis of Quality. An Introduction*. Chichester, UK: John Wiley & Sons.
- Martens, M. (1999). A philosophy for sensory science. *Food Quality and Preference*, 10(4-5), 233-244.
- McEwan, J. A. (1996). Preference mapping for product optimization. In T. Næs, & E. Risvik (Eds.), *Multivariate Analysis of Data in Sensory Science* (Vol. 16). Amsterdam, NL: Elsevier Science B.V., Chap. 3, pp. 71-102.
- Meilgaard, M., Civille, G. V., & Carr, B. T. (1999). *Sensory Evaluation Techniques* (3rd ed.). Boca Raton, FL: CRC Press LLC.
- Meiselman, H. L., Johnson, J. L., Reeve, W., & Crouch, J. E. (2000). Demonstrations of the influence of the eating environment on food acceptance. *Appetite*, 35(3), 231-237.
- Mela, D. J. (2000). Why do we like what we like? *Journal of the Science of Food and Agriculture*, 81(1), 10-16.
- Mojet, J., & Köster, E. P. (2002). Texture and flavour memory in foods: An incidental learning experiment. *Appetite*, 38(2), 110-117.
- Mojet, J., & Köster, E. P. (2005). Sensory memory and food texture. *Food Quality and Preference*, 16(3), 251-266.
- Morin-Audebrand, L., Laureati, M., Sulmont-Rossé, C., Issanchou, S., Köster, E. P., & Mojet, J. (2009). Different sensory aspects of a food are not remembered with equal acuity. *Food Quality and Preference*, 20(2), 92-99.
- Musher-Eizenman, D. R., de Lauzon-Guillain, B., Holub, S. C., Leporc, E., & Charles, M. A. (2009). Child and parent characteristics related to parental feeding practices. A cross-cultural examination in the US and France. *Appetite*, 52(1), 89-95.
- Møller, P., & Hausner, H. (2006). Memory of sweetness and fatty flavours: Effects of gender and liking. *Food Quality and Preference*, 17(7-8), 653-654.
- Møller, P., Mojet, J., & Köster, E. P. (2007). Incidental and Intentional Flavor Memory in Young and Older Subjects. *Chemical Senses*, 32(6), 557-567.
- Møller, P., Wulff, C., & Köster, E. P. (2004). Do age differences in odour memory depend on differences in verbal memory? *Neuroreport*, 15(5), 915-917.
- Napolitano, F., Caporale, G., Carlucci, A., & Monteleone, E. (2007). Effect of information about animal welfare and product nutritional properties on acceptability of meat from Podolian cattle. *Food Quality and Preference*, 18(2), 305-312.
- Nielsen, H. B., Sonne, A.-M., Grunert, K. G., Banati, D., Pollák-Tóth, A., Lakner, Z., Olsen, N. V., Žontar, T. P., & Peterman, M. (2009). Consumer perception of the use of high-pressure processing and pulsed electric field technologies in food production. *Appetite*, 52(1), 115-126.
- Næs, T., & Langsrud, Ø. (1998). Fixed or random assessors in sensory profiling? *Food Quality and Preference*, 9(3), 145-152.

- Næs, T., & Risvik, E. (1996). *Multivariate Analysis of Data in Sensory Science* (Vol. 16). Amsterdam, NL: Elsevier Science B.V.
- O'Mahony, M. (1986). *Sensory Evaluation of Food: Statistical Methods and Procedures*. New York, NY: Marcel Dekker Inc.
- Oakes, M. E., & Slotterback, C. S. (2001a). Judgements of food healthfulness: food name stereotypes in adults over age 25. *Appetite*, *37*(1), 1-8.
- Oakes, M. E., & Slotterback, C. S. (2001b). What's in a name? A comparison of men's and women's judgements about food names and their nutrient contents. *Appetite*, *36*(1), 29-40.
- Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preference. *Food Technology, Symposium, September*, 9-14.
- Pliner, P., & Hobden, K. (1992). Development of a Scale to Measure the Trait of Food Neophobia in Humans. *Appetite*, *19*(2), 105-120.
- Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, *19*(8), 459-466.
- Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: a comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference*, *13*(7), 489-495.
- Provencher, V., Polivy, J., & Herman, C. P. (2009). Perceived healthiness of food. If it's healthy, you can eat more! *Appetite*, *52*(2), 340-344.
- Ritvanen, T., Lampolahti, S., Lilleberg, L., Tupasela, T., Isoniemi, M., Appelbye, U., Lyytikäinen, T., Eerola, S., & Uusi-Rauva, E. (2005). Sensory evaluation, chemical composition and consumer acceptance of full fat and reduced fat cheeses in the Finnish market. *Food Quality and Preference*, *16*(6), 479-492.
- Roininen, K., Lähteenmäki, L., & Tuorila, H. (1999). Quantification of Consumer Attitudes to Health and Hedonic Characteristics of Foods. *Appetite*, *33*(1), 71-88.
- Roininen, K., Lähteenmäki, L., & Tuorila, H. (2000). An application of means-end chain approach to consumers' orientation to health and hedonic characteristics of foods. *Ecology of Food and Nutrition*, *39*(1), 61-81.
- Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American Conceptions of Nutrition: Dose Insensitivity, Categorical Thinking, Contagion, and the Monotonic Mind. *Health Psychology*, *15*(6), 438-447.
- Rozin, P., Fischler, C., Imada, S., Sarubin, A., & Wrzesniewski, A. (1999). Attitudes to Food and the Role of Food in Life in the U.S.A., Japan, Flemish Belgium and France: Possible Implications for the Diet-Health Debate. *Appetite*, *33*(2), 163-180.
- Schifferstein, H. N. J. (2001). Effects of Product Beliefs on Product Perception and Liking. In L. J. Frewer, E. Risvik, & H. Schifferstein (Eds.), *Food, People and Society: A European Perspective of Consumers' Food Choices*. Berlin, DE: Springer-Verlag, Chap. 5, pp. 73-96.
- Schifferstein, H. N. J., Kole, A. P. W., & Mojet, J. (1999). Asymmetry in the Disconfirmation of Expectations for Natural Yogurt. *Appetite*, *32*(3), 307-329.

- Schiffman, H. R. (1996). *Sensation and Perception: An Integrated Approach* (4th ed.). New York, NY: John Wiley & Sons.
- Schnettler, B., Vidal, R., Silva, R., Vallejos, L., & Sepúlveda, N. (2009). Consumer willingness to pay for beef meat in a developing country: The effect of information regarding country of origin, price and animal handling prior to slaughter. *Food Quality and Preference*, 20(2), 156-165.
- Shepherd, R., Sparks, P., Bellier, S., & Raats, M. M. (1991/2). The effects of information on sensory ratings and preferences: the importance of attitudes. *Food Quality and Preference*, 3(3), 147-155.
- Siret, F. (2004). *Contribution à l'étude du concept de tradition en charcuterie cuite. Deux exemples: le jambon cuit et le pâté de campagne*. Thèses de doctorat, Université de Bourgogne, Dijon, France.
- Sobal, J. (1998). Cultural comparison research designs in food, eating, and nutrition. *Food Quality and Preference*, 9(6), 385-392.
- Solheim, R. (1992). Consumer Liking for Sausages Affected by Sensory Quality and Information on Fat Content. *Appetite*, 19(3), 285-292.
- Solheim, R., & Lawless, H. T. (1996). Consumer purchase probability affected by attitude towards low-fat foods, liking, private body consciousness and information on fat and price. *Food Quality and Preference*, 7(2), 137-143.
- Stefani, G., Romano, D., & Cavicchi, A. (2006). Consumer expectations, liking and willingness to pay for specialty foods: Do sensory characteristics tell the whole story? *Food Quality and Preference*, 17(1-2), 53-62.
- Steiner, J. E. (1974). Discussion paper: innate, discriminative human facial expressions to taste and smell stimulation. *Annals of the New York Academy of Sciences*, 237, 229-233.
- Stephoe, A., Pollard, T. M., & Wardle, J. (1995). Development of a Measure of the Motives Underlying the Selection of Food: the Food Choice Questionnaire. *Appetite*, 25(3), 267-284.
- Sulmont-Rossé, C., Møller, P., Issanchou, S., & Köster, E. P. (2008). Effect of Age and Food Novelty on Food Memory. *Chemosensory Perception*, 1(3), 199-209.
- Sulmont, C., Issanchou, S., & Köster, E. P. (2002). Selection of Odorants for Memory Tests on the Basis of Familiarity, Perceived Complexity, Pleasantness, Similarity and Identification. *Chemical Senses*, 27(4), 307-317.
- Sun, Y.-H. C. (2008). Health concern, food choice motives, and attitudes toward healthy eating: The mediating role of food choice motives. *Appetite*, 51(1), 42-49.
- Tuorila, H., Cardello, A. V., & Leshner, L. L. (1994). Antecedents and Consequences of Expectations Related to Fat-free and Regular-fat Foods. *Appetite*, 23(3), 247-263.
- Tuorila, H., Sommar Dahl, C., Hyvönen, L., Leporanta, K., & Merimaa, P. (1993). Sensory attributes and acceptance of sucrose and fat in strawberry yoghurts. *International Journal of Food Science and Technology*, 28(4), 359-369.
- Tuorila, H. M., Meiselman, H. L., Cardello, A. V., & Leshner, L. L. (1998). Effect of expectations and the definition of product category on the acceptance of unfamiliar foods. *Food Quality and Preference*, 9(6), 421-430.

- Urala, N., Arvola, A., & Lähteenmäki, L. (2003). Strength of health-related claims and their perceived advantage. *International Journal of Food Science and Technology*, *38*(7), 815-826.
- Urala, N., & Lähteenmäki, L. (2006). Hedonic ratings and perceived healthiness in experimental functional food choices. *Appetite*, *47*(3), 302-314.
- van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for Assessment of Restrained, Emotional, and External Eating Behavior. *International Journal of Eating Disorders*, *5*(2), 295-315.
- van Trijp, H. C. M., & Schifferstein, H. N. J. (1995). Sensory analysis in marketing practice: comparison and integration. *Journal of Sensory Studies*, *10*(2), 127-147.
- Vickers, Z., Holton, E., & Wang, J. (2001). Effect of ideal-relative sweetness on yogurt consumption. *Food Quality and Preference*, *12*(8), 521-526.
- Visschers, V. H. M., & Siegrist, M. (2009). Applying the evaluability principle to nutrition table information. How reference information changes people's perception of food products. *Appetite*, *52*(2), 505-512.
- Wansink, B. (2003). Response to "Measuring consumer response to food products". Sensory tests that predict consumer acceptance. *Food Quality and Preference*, *14*(1), 23-26.
- Wedel, M., & Kamakura, W. A. (1998). *Market Segmentation: Conceptual and Methodological Foundations*. Boston: Kluwer Academic Publishers.
- Wedel, M., & Steenkamp, J.-B. E. M. (1989). A fuzzy clusterwise regression approach to benefit segmentation. *International Journal of Research in Marketing*, *6*(4), 241-258.
- Wedel, M., & Steenkamp, J.-B. E. M. (1991). A Clusterwise Regression Method for Simultaneous Fuzzy Market Structuring and Benefit Segmentation. *Journal of Marketing Research*, *28*(4), 385-396.
- Westad, F., Hersleth, M., Lea, P., & Martens, H. (2003). Variable selection in PCA in sensory descriptive and consumer data. *Food Quality and Preference*, *14*(5-6), 463-472.
- Westcombe, A., & Wardle, J. (1997). Influence of Relative Fat Content Information on Responses to Three Foods. *Appetite*, *28*(1), 49-62.
- Whetstone, M. E. C., Drake, M. A., Nelson, B. K., & Barbano, D. M. (2006). Flavor Profiles of Full-Fat and Reduced-Fat Cheese and Cheese Fat Made from Aged Cheddar with the Fat Removed Using a Novel Process. *Journal of Dairy Science*, *89*(2), 505-517.
- Wilcock, A., Pun, M., Khanona, J., & Aung, M. (2004). Consumer attitudes, knowledge and behaviour: a review of food safety issues. *Trends in Food Science & Technology*, *15*(2), 56-66.
- Aaron, J. I., Mela, D. J., & Evans, R. E. (1994). The Influences of Attitudes, Beliefs and Label Information on Perceptions of Reduced-fat Spread. *Appetite*, *22*(1), 25-37.

Abstracts of papers

Paper I

Motivation for choice and healthiness perception of calorie-reduced dairy products - a cross-cultural study

Understanding consumers' motives for selecting calorie-reduced dairy products is important to provide targeted communication for different consumer segments. The aim of this study was to identify motives for consumption of calorie-reduced dairy products among young consumers, and to identify how these consumers perceive the healthiness of such products compared to other food products. Consumers, aged 18 to 30 years, in Norway (n=118), Denmark (n=125), and California (n=127) participated in a dual sorting and a ranking test. The respondents sorted 24 statements referring to motives for choosing calorie-reduced yoghurt and cheese. The study also assessed the aspect of perceived healthiness of these products in comparison with a selection of other food products using a two step ranking procedure. Data were analysed using chi-square analysis, Friedman's test and principal component analysis (PCA). Results showed that fat content, healthiness and taste were the most important motivators for choice of calorie-reduced dairy products. In all three countries salmon was perceived as the healthiest among the products presented. Although cross-cultural differences existed in motives for choice and perceived healthiness of the products, the similarities between the countries were evident in this study.

Paper II

A new approach to product set selection and segmentation in preference mapping

A common problem in food product development is to identify the consumers' drivers of liking and to understand in what way they relate to the acceptance data. Usually, one will also be interested in identifying segments of consumers. The main objective of this study was to investigate the use of fuzzy clustering within the area of preference mapping when different consumer groups test different sets of products. A case study on low-fat cheese was used to explore and illustrate the proposed approach. Two groups of 57 and 58 consumers, respectively, participated in the consumer test. Based on sensory profiling, different cheese products evenly distributed in the sensory space were selected for each group. Each consumer rated their acceptance based on a blind tasting of six cheeses. One of the segments was identified to have a linear preference pattern, while the other two had non-linear patterns.

Paper III

Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information

The main objective of this paper was to study acceptance of yoghurt with different levels of two specific sensory attributes, sweetness and richness, when corresponding information about sugar and fat content was given simultaneously with tasting. A conjoint design was applied to examine the effects of intrinsic attributes (sensory) and extrinsic attributes (health information) on acceptability and purchase probability for calorie reduced vanilla yoghurt. Based on sensory profiling of 12 yoghurts produced according to an experimental design, four yoghurts varying in sweetness and richness were selected. In the conjoint study this sensory variation was combined with information concerning fat content and sugar content. 153 health conscious consumers participated in a blind testing and a conjoint study. Analyses of variance showed that sweetness and information about sugar content had significant effects on liking and purchase probability. The study showed that conjoint methodology was an appropriate tool to reveal effects of extrinsic and intrinsic product attributes.

Paper IV

Effects of information about fat percentage on acceptance of low-fat cheese

The main objective of this study was to investigate the effect of information about fat content on consumer acceptance of a selection of low-fat cheeses. Seventeen low-fat (5% - 17%) cheeses, either experimentally produced or available on the Scandinavian market, were evaluated by a trained panel using descriptive sensory analysis. Based on the results of the profiling, twelve cheeses were selected for the consumer study. The consumers (n=114) rated degree of liking for the cheeses, both without and with being given information concerning the cheeses' fat content. Principal component analysis revealed independence between the sensory profile and fat content of the cheeses. On average, the consumers preferred cheeses with a cream and acidic flavour and a fatty and sticky consistency. Generally, being given information about fat content had a negative effect on liking, only for the most sensory appealing cheeses was a tendency for positive effect was observed. Consumer segments with different responses to the interaction between sensory profile and information were found.

Paper I

Motivation for choice and healthiness perception of calorie-reduced dairy products - a cross-cultural study

Susanne Bølling Johansen^{a,b,1}, Tormod Næs^a and Margrethe Hersleth^{a,b}

^a Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway

^b Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway

Abstract

Understanding consumers' motives for selecting calorie-reduced dairy products is important to provide targeted communication for different consumer segments. The aim of this study was to identify motives for consumption of calorie-reduced dairy products among young consumers, and to identify how these consumers perceive the healthiness of such products compared to other food products. Consumers, aged 18 to 30 years, from Norway (n=118), Denmark (n=125), and California (n=127) participated in a dual sorting and a ranking test. The respondents sorted 24 statements referring to motives for choosing calorie-reduced yoghurt and cheese. The study also assessed the aspect of perceived healthiness of these products in comparison with a selection of other food products using a two step ranking procedure. Data were analysed using chi-square analysis, Friedman's test and principal component analysis (PCA). Results showed that fat content, healthiness and taste were the most important motivators for choice of calorie-reduced dairy products. In all three countries salmon was perceived as the healthiest among the products presented. Although cross-cultural differences existed in motives for choice and perceived healthiness of the products, the similarities between the countries were evident in this study.

Keywords: Cross-culture, Motivation, Healthiness perception, Calorie-reduced, Dairy

¹ Corresponding author at: Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway
E-mail address: susanne.johansen@nofima.no (S. Johansen).

1. Introduction

Food is critical to sustain life, but also a source of pleasure, worry and stress (Rozin, Fischler, Imada, Sarubin, & Wrzesniewski, 1999). For most people, food choice is a part of everyday life, and we perform this task with different levels of consciousness. Food choice is a complex process influenced by a number of factors related to the product (intrinsic and extrinsic properties), the consumer (e.g. knowledge, beliefs, attitudes), and the planned consumption context (e.g. occasion, cultural environment) (Jaeger & Rose, 2008; Mela, 1999; Pollard, Kirk, & Cade, 2002). Knowledge, beliefs and attitudes to food are results of cultural background, eating habits established during childhood and the constant flow of information about food in daily life (Axelson, 1986; Lappalainen, Kearney, & Gibney, 1998; Sobal, 1998). The motivation for food choice may be influenced by an interest in health, weight concern, sensory pleasure, ideological reasons, convenience, price or familiarity (Crossley & Khan, 2001; Lindeman & Stark, 1999). Different models for consumer behaviour have been developed (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and a number of publications estimating the relative importance of different factors have been published (Dennison & Shepherd, 1995; Guerrero et al., 1998; Shepherd, 1999). Health related aspects of food choice will be the main focus in the present paper.

An important aspect that gradually influences food choice is the focus on health and weight control. This induces a continuous development of calorie-reduced products targeted an increasingly health conscious market. It is shown, however, that the motives for food choice can be related to a larger extent to consumers' personality and lifestyle (Brunso, Scholderer, & Grunert, 2004; Lindeman & Sirelius, 2001). Gender, age, social class and income are often underlying factors explaining food choice motives. Women seem more concerned with diet, weight and health control (Rozin et al., 1999; Steptoe, Pollard, & Wardle, 1995) and associate "food" with "fat", while men have a tendency to focus more on pleasure and sensory perception (Rozin, Kurzer, & Cohen, 2002). Young consumers seem to be less health conscious and more biased in their health expectations related to foods (Groth et al., 2009; Rozin et al., 2002) compared to older consumers. Especially at the beginning of independent living, young consumers' food choice is primarily based on price (Sharma, Harker, Harker, & Reinhard, 2009). Regarding influence of social class and income on food choice, higher socioeconomic groups seem to be more motivated by ideological factors like natural ingredients and ethical concerns, while lower socioeconomic groups focus on convenience, price and familiarity (Crossley & Khan, 2001).

To simplify food evaluation and choice, consumers develop different strategies (Furst, Connors, Bisogni, Sobal, & Falk, 1996). For instance, it is common for individuals to categorize foods according to health or diet using good-bad dichotomy based on specific food qualities (Ross & Murphy, 1999; Rozin, Ashmore, & Markwith, 1996). A series of studies by Oakes and Slotterback

(2001a, 2001b, 2001c, 2002) have shown that the reputation as good or bad is influenced by the foods' fat content. Furthermore, people's food-related motives, like improving health or losing weight, are likely to influence their perception and rating of food (Carels, Konrad, & Harper, 2007; Oakes & Slotterback, 2002). For example, when judging foods' healthfulness, dieters tend to rate fat content as most important, whereas non-dieters rate freshness (Oakes & Slotterback, 2002). Nutritional information is therefore expected to influence consumer perception and acceptance of health improved foods. For dairy products the importance of health and nutritional information related to fat has been confirmed for acceptance of cheese (Light, Heymann, & Holt, 1992; Vickers & Mullan, 1997), but not to the same degree for yoghurt (Haddad et al., 2007; Kähkönen, Tuorila, & Lawless, 1997; Westcombe & Wardle, 1997). Therefore, information on calorie reduction may affect consumer acceptance but with strong dependence on the type of food product (Wansink, 2003) and how unhealthy the original product was perceived.

In recent decades, the food industry throughout the world has expanded the production of calorie-reduced products to meet the growing demands for healthier foods. Low-fat and non-fat food products, such as calorie-reduced yoghurt and cheese, have been produced and sold in the US since the 1980s (La Berge, 2008). In Denmark, calorie-reduced yoghurt and cheese have been sold since the late 1980s, while these products were not launched in Norway before the 1990s. At the same time, authorities have spent considerable resources on health campaigns to increase knowledge and change public attitude towards healthier eating as health information and its perception are crucial to consumers' ability to make informed food choices. However, the major sources of health information in the Northern European countries are still the media (Lappalainen et al., 1998). Media are often a source of conflicting information about food, nutrition and health, resulting in beliefs and attitudes about the healthiness of foods that may diverge from fact (Oakes & Slotterback, 2001b, 2001c). In particular, young adults seem to have biased healthiness expectations about foods (Oakes & Slotterback, 2001b), which may result from biased beliefs about foods. Availability and familiarity with healthier product alternatives also contribute to health perception of consumers. Therefore, it is of interest to investigate how young consumers, from countries with different traditions for marketing of healthy products, perceive and relate to calorie-reduced dairy products marketed as healthier alternatives to the original products.

The purpose of the present work was to identify young consumers' motives for choosing calorie-reduced yoghurt and cheese and to identify how young consumers' perceive the healthiness of these products compared to other foods. The study was conducted in Norway, Denmark and California in order to compare young consumers from three different countries all representing Western cultures. Accordingly, country peculiarities will be elaborated and discussed.

2. Materials and methods

This study consists of two parts. In the first part, young consumers' motives for selecting calorie-reduced yoghurt and cheese were studied by dual sorting test, a method previously used by Siret (2004) and Sulmont-Rossé et al. (2007) to identify respectively consumers' representations of traditional delicatessen and food products. In the second part, perceived healthiness of the same products was compared to other food products by ranking test (O'Mahony, 1986).

2.1. Respondents

Young consumers, students at local universities, were recruited in Norway (Oslo), Denmark (Copenhagen) and the US, California (Davis). Participants were selected based on 1) age 18 to 30 years, and 2) that they were consumers of low or non-fat yoghurt or cheese (\geq once a month). Students of food science or nutritional science were not included in the study. The numbers of respondents in each country were as follows; Norway (n=118; 34 males, 84 females), Denmark (n=125; 36 males, 89 females) and California (n=127; 42 males, 85 females).

2.2. Procedure for data collection

The data collection was conducted by the same person over a period of 9 months in all three countries with a test duration of 1-2 weeks at each location. The tests were conducted as central location tests and took place at the universities in canteens, halls or corridors. Students were contacted on site by asking if they were consumers of low or non-fat yoghurt or cheese and interested in participating in a consumer study. Students that passed the inclusion criteria received an identification number which was used throughout the study. The main part of the data collection (dual sorting tests and ranking test) was performed using a computer program, followed up by a written socio-demographic questionnaire. The test was presented in the native language of each country. Prior to the test all texts (statements, products and socio-demographic questions) were translated into the national languages using back-translation to ensure linguistic equivalence (Brislin, 1970). All respondents started with the dual sorting test, half of the sample started with cheese and the other half with yoghurt (randomly assigned). Immediately after completion of the dual sorting test the ranking test followed. Finally, a questionnaire was presented which included both sociographic and demographic data (gender, age, field of study), together with supplementary questions on the frequency of calorie-reduced yoghurt and cheese usage.

2.3. Dual sorting test

To identify motives for choosing calorie-reduced yoghurt and cheese the dual sorting test (Siret, 2004) was used. The Food Choice Questionnaire (FCQ) developed by Steptoe, Pollard, and Wardle (1995) was used as a validated basis for selecting possible relevant motive-related statements. A total of 22 statements

from the FCQ related to health, mood, convenience, sensory appeal, natural content, price, weight control and familiarity were selected (see Table 1). Two additional motives expected to be important were included: “It suits my lifestyle” as a possible relevant motive for young consumers and “It is low in sugar” as a result of the increased focus on sugar in yoghurt. Table 1 gives a full overview of the 24 statements presented.

The dual sorting test was used because it is a stepwise approach which simplifies the procedure for the consumer. The dual sorting test consisted of three steps (see Fig. 1.). In the first step the respondents were asked to select the 12 most important motives for choice of yoghurt/cheese from a total list of 24 statements. In the next step, 6 of the previous 12 selected statements should be selected, and in the final step, 3 of the previous 6 selected statements should be selected. It was possible to change selection of responses within each step of the test, but not between steps.

2.4. Product ranking

The perceived healthiness of calorie-reduced yoghurt and cheese compared to other selected food products were studied using a ranking test (O'Mahony, 1986). Altogether, 15 food products (see Table 2) were ranked according to perceived healthiness of the products using a two-step ranking test (see Fig. 2.). The selection of the food products presented was done according to the following criteria 1) the products should be on the market in all three countries, 2) the products should represent a mixture of products rich in protein, carbohydrate or fat and 3) the product could represent food or beverages. Due to the relatively large number of products the ranking was done in two steps. In the first step, the consumers were asked to group the products into three groups of 5 products according to healthiness (most, medium and least healthy). In the second step the consumers were asked to do a ranking of the products within each group separately (from most to least healthy).

2.5. Statistical analyses

2.5.1. Dual sorting data

The data from the dual sorting test were analysed by a chi-square goodness-of-fit test (Minitab 15.1, State College, Pennsylvania, USA). In the chi-square analysis each country and statement were analysed separately. The null hypothesis is that no systematic tendencies are present, only chance associated with each sorting step. This leads to theoretical frequencies equal to 0.5, 0.25 and 0.125 for the three sorting steps.

Multivariate analysis was performed using principal component analysis (PCA) in the Unscrambler version 9.8 (Camo AS, Oslo, Norway). The PCA was used on a

data matrix with 12 rows corresponding to the four sorting categories (score equals 0, 1, 2 and 3) for all three countries. The columns correspond to the different statements. The entries were the percentages of the different statements for each of the sorting categories. The sum of entries in a row is therefore equal to 100%. The data were mean centred, not standardised (Mardia, Kent, & Bibby, 1980) and full cross validation (Martens & Næs, 1989) was used for validation of the components.

Nominal logistic regression (Minitab 15.1, State College, Pennsylvania, USA) was performed on each statement separately with country and gender as factors and a significance level equal to 0.05. Results are shown for gender, while significant differences for country only are discussed shortly. The category score equal to zero was used as reference event. An evaluation of the overall model was given as well as the effect of country and gender within the comparison of each category with the reference event. In the following we will only focus on the results for the last category (score equals 3).

2.5.2. Ranking data

The ranking data from each country were analysed using Friedman test (SYSTAT 9, Chicago, USA) for calculation of significance in the rank sums (R_i and $R_{i'}$), followed by multiple comparison of the 15 products using formula 2.26 in Hochberg and Tamhane (1987) for within-block rank statistics. For comparison of rank sums the formula can be written as follows:

$$|R_i - R_{i'}| > \frac{n Q_{k,\infty}^{(\alpha)}}{\sqrt{2}} \sqrt{\frac{k(k+1)}{6n}} \quad (1 \leq i < i' \leq k),$$

where k is the number of samples, n is the number of consumers and $\alpha = 0.05$ is the significance level.

3. Results

First the results from the dual sorting test on motives for choosing calorie-reduced dairy products will be presented. Subsequently, we present the results from the ranking test on perceived healthiness of these products compared to other foods.

3.1. Motives for choosing calorie-reduced dairy products - dual sorting test

Results from the dual sorting test on yoghurt and cheese can be seen in Table 3 and Table 4. The tables shows, across all three countries, that the three most important motives for choosing calorie-reduced yoghurt and cheese were “It is low in fat”, “It keeps me healthy”, and “It tastes good”. Other important motives were “It helps to control my weight”, “It is nutritious”, “It is easily available in

shops” and “It suits my lifestyle” (see Table 3 and 4), respectively. In all three countries the least important motive for choosing calorie-reduced yoghurt and cheese was “It helps me cope with stress”, while the second least important motive across countries for both products was “It smells nice”.

To study the country differences with regard to priority of the different statements at each sorting step, a PCA on the percentage distribution of categories was performed. In addition, the results from the nominal logistic regression on significant differences between the countries were allowed for (stated below). The correlation loading plots of the data for yoghurt are presented in Fig. 3a. and Fig. 3b. The first two principal components show the general relationship between statements and sorting steps for which no major difference can be seen between countries. However, the third principal component reveals that the consumers from California prioritised statements somewhat differently compared to consumers from Denmark and Norway. The motives “It is nutritious” and “It takes no time to prepare” were prioritised significantly higher in California than in the other countries. On the other hand, the motives “It is low in fat”, “It helps me control my weight” and “It is low in sugar” were prioritised significantly higher in Denmark and Norway, while only the Danish students prioritised the motive “It suits my lifestyle” significantly higher than the Californian students. Corresponding correlation loadings plots of data for cheese showed similar patterns, i.e. the same differences in priorities between California on the one side and Denmark and Norway on the other side. Significant differences were only seen between California and Denmark for “It is nutritious”, “It is low in sugar” and “It helps me control my weight” (results not shown).

Fig. 4. shows the number of times within each country a statement was one of the three main motives for consuming calorie-reduced yoghurt (score equal to 3). The order of the statements is sorted with respect to overall mean score, shown in Table 3. As can be seen, differences in priorities exist between countries. The majority of respondents from Denmark prioritised the statement “It is low in fat” as most important, followed by “It keeps me healthy, “It helps me control my weight” (significantly higher prioritised by Danes) and “It tastes good”, of which the latter two were almost equally prioritised. For the Norwegian respondents “It is low in fat” was highly prioritised, followed by “It is low in sugar” and “It tastes good”. For Californian respondents, the three most and almost equally prioritised motives for choosing calorie-reduced yoghurt were “It is low in fat”, “It tastes good” and “It is nutritious” (see Fig. 4). A corresponding diagram for calorie-reduced cheese showed the same pattern to some degree, but more similarities between countries were revealed (results not shown).

Results from the analysis on gender differences in motives for choosing calorie-reduced yoghurt and cheese are shown in Table 5. As can be seen, the statements “It is low in fat” and “It helps me control my weight” were prioritised

significantly higher by the female students than the male students for both dairy products.

3.2. Product ranking

Results from the product ranking are presented in Table 6. The table shows that salmon is perceived as the healthiest of the products presented in all three countries. Non-fat or low-fat yoghurt and milk were perceived as the second and the third most healthy products in California (only milk was significantly different from salmon) and in Denmark (none of them were significantly different from salmon). In Norway, avocado was ranked as number two (not significant), egg as number three (significant), non-fat or low-fat yoghurt as number four (significant), while milk had a lower ranking. Table 6 shows that the following products were given the lowest ranking in all three countries: beer, wine, pasta and pork.

When focusing on non-fat or low-fat yoghurt and cheese and levels of significance, the table shows that non-fat or low-fat yoghurt were given a high ranking (equal to salmon), both in California and Denmark, and ranked among the second healthiest products in Norway (significant). Non-fat or low-fat cheese was ranked in the middle of all the 15 selected products with regard to healthiness, but the difference in ranking of cheese compared to yogurt was only significant in California.

4. Discussion

The purpose of this study was to identify young consumers' motives for selecting calorie-reduced yoghurt and cheese and to identify how young consumers' perceive the healthiness of these products compared to other foods. Below, we will first discuss important motives, then perceived healthiness and finally we will discuss relationship between these two elements.

4.1. Motives for choosing calorie-reduced dairy products

4.1.1. Important motives across countries

The overall results across countries showed that young consumers' main motives for choosing calorie-reduced yoghurt and cheese were related to low fat content, healthiness and good taste. Moreover, weight control, nutritional aspects, availability and lifestyle seemed to be important motives. The original FCQ was developed as a multidimensional measure of motives related to food choice and the questionnaire focuses on nine factors in total, each of them comprising several items (questions). In the present study the purpose has been to identify motives for choosing specific products. The FCQ was therefore merely used as a validated basis for selecting possible relevant motives. Accordingly, the interpretation of the

results must be limited to a discussion on each item (motive), not a discussion of the original factors.

Health and nutritional aspects

In general, several studies have shown that healthiness is an important motive for food choice (Ares & Gámbaro, 2007; Prescott, Young, O'Neill, Yau, & Stevens, 2002). This has been especially evident for older consumers (Honkanen & Frewer, 2009), possibly induced by their increased risk for disease and thus concern for health (Roininen, Lähteenmäki, & Tuorila, 1999). Similar results have also been seen for yoghurt as a product category. Pohjanheimo & Sandell (2009) showed that not only healthiness but also nutritious composition were highly important motives for older consumers, while healthiness and weight control only were moderately important motives for young consumers. Similarly, Sun (2008) studied Asian people and found that weight control may be less important for young adults, however, this result was based on motives for food choice in general and thus not product specific. The consumer sample in the present study only included younger consumers which makes it impossible to look for any age effects.

Focusing on calorie-reduced dairy products, Roininen, Lahtenmaki and Tuorila (2000) found that these products are perceived as healthy, non pleasure-giving foods associated with low-fat content and high nutritional value. Yoghurt in particular, is generally associated with healthiness (Ares, Giménez, & Gámbaro, 2008), while the calorie-reduced types in addition may be associated with slimming effects (Ares et al., 2008). Our results coincide well with these previous findings. Furthermore, we found that women prioritised low fat content and weight control as significantly more important motives for consuming calorie-reduced yoghurt and cheese compared to men (Table 5). This result supports earlier findings showing that women are more concerned about fat content and weight control than men (Rozin et al., 1999; Steptoe et al., 1995) and when judging food names women tend to focus negatively on dietary fat, whereas men consider the total nutritional content (Oakes & Slotterback, 2001b). Other studies support the finding that women are more interested in health than men (Ares et al., 2008; Roininen et al., 1999). The same studies also found that women had higher interest in nutritional content (Ares et al., 2008) and taste aspects of foods (Roininen et al., 1999). This is in contrast to the findings in the present study, as we found no significant gender differences for these motives.

Sensory aspects

Results from the present study showed that good taste was one of the main motives for young consumers' choice of calorie-reduced yoghurt and cheese. For choice of food in general, several studies have shown that sensory appeal is a main determinant (Honkanen & Frewer, 2009; Johansen, Næs, Øyaas, & Hersleth,

2010; Prescott et al., 2002; Sun, 2008). Particularly for regular (full-fat) yoghurt similar results have been observed (Ares & Gámbaro, 2007; Ares et al., 2008). However, for calorie-reduced yoghurt additional associations like sensory defects and bad taste have been found (Ares et al., 2008; Roininen et al., 2000). Such associations do not fit well with our result that good taste was one of the main motives for choice of calorie-reduced yoghurt and cheese. However, a plausible explanation for our finding may be that the respondents all were consumers of these products and thus have become used to the taste and find it pleasant.

Availability and lifestyle

Results from the dual sorting task showed that product availability and suitability for people's lifestyles were relatively important motives across all three countries for choice of calorie-reduced yoghurt and cheese. Finding lifestyle among the important factors for choice of calorie-reduced products seems reasonable, since a study by Lindeman & Sirelius (2001) suggested that food choice increasingly is a way of expressing one's philosophy of life. Also interesting was that availability was an important factor. A recent study on Russian consumers found availability as the second most important motive for food choice in general (Honkanen & Frewer, 2009). Our result could either suggest that the consumers want higher availability of calorie-reduced dairy products, or it could be an expression of the need for accessibility as a basis for choice.

Less important motives

The least important motive for choosing calorie-reduced yoghurt and cheese was the mood related statement "It helps me cope with stress". That mood may be less relevant for food choice is supported by a cross-cultural study by Prescott, Young, O'Neill, Yau and Stevens (2002). They studied motives for food choice in general, thus not motivation for the choice of specific foods, and found that among the less important factors were familiarity, ethical concern and mood. However, it is relevant to mention that the low priority is relative and not absolute. Thus, it may still be important.

4.1.2. Country specific results

Relatively small differences were observed between the three countries. In particular, the respondents from Denmark and Norway prioritised many of the same motives, especially for the cheese data. Some peculiarities were shown for Californian respondents e.g. the statement "It is nutritious" was given a significantly higher priority in California than in Scandinavia. The reason may be a stronger focus on nutrition in the US than in Europe (Bruhn et al., 1992; Musher-Eizenman, de Lauzon-Guillain, Holub, Leporc, & Charles, 2009).

The statements “It is low in sugar” and “It suits my lifestyle” both proved to be important motives for the Scandinavian students. The statement “It is low in sugar” was given a significantly higher priority by the Norwegian and Danish respondents than by the Californian respondents. This result may reflect a recent high focus on unhealthiness associated with high sugar content in yoghurt by Scandinavian media, especially in Norway. The Danish students prioritised the statements “It suits my lifestyle” and “It helps me control my weight” significantly higher than Californian students. The reason for including the lifestyle statement in this study was that motives for food choice increasingly have been shown to be related to consumers’ personality and philosophy of life (Brunsø et al., 2004; Lindeman & Sirelius, 2001). According to Lindeman and Sirelius (2001) food choice based on health-consciousness and weight-consciousness is an act of conforming to social norms and pressure, as slimness and health have come to represent virtue, success and status in the Western world. Our results indicate that this desire for social acceptance is a strong motivator among Danish students.

4.2. Perceived healthiness of calorie-reduced dairy products

In all three countries salmon was ranked as the healthiest product. For the dairy products, which have the main attention in this study, only calorie-reduced yoghurt was ranked among the healthiest products by the respondents from California and Denmark. Earlier studies conducted in Finland and Switzerland showed that yoghurt is perceived as a relatively healthy product (Kähkönen et al., 1997; Visschers & Siegrist, 2009). The reason for the ranking of calorie-reduced yoghurt in Norway as being less healthy may be explained by the media’s focus on sugar content of yoghurt (including calorie-reduced) at the time before the study was conducted. In all three countries calorie-reduced yoghurt was ranked as healthier than calorie-reduced cheese. However, a significant difference in perceived healthiness was only observed for the Californian respondents. This supports the finding by Westcombe & Wardle (1997) who studied the influence of relative fat content information on responses (e.g. perceived healthiness) to yoghurt and cheese as well as other products. This study showed that healthiness of yoghurt was rated higher than for cheese, independent of the labelled fat content (low, normal or high).

Perception of salmon as a healthy product was supported by several publications showing that fish has a healthy reputation among consumers (Brunsø, Verbeke, Olsen, & Jeppesen, 2009; Pieniak, Verbeke, Perez-Cueto, Brunsø, & De Henauw, 2008; Verbeke, Sioen, Pieniak, Van Camp, & De Henauw, 2005). The result in this study also suggest that the respondents have focused primarily on the healthy aspects of salmon (rich in protein, omega-3 fatty acids and vitamin D) and not on the unhealthy (fats in large quantities and possible content of toxins like dioxins and heavy metals). This does not support the findings by Verbeke et al. (2005) that consumers are more aware of the content and effect of harmful substances than of nutrients in fish. The reason for our finding may be linked to increased

media focus on the health benefits of fish and the official nutritional recommendation of weekly consumption of fish.

Consumer attitudes to food, nutrition and health have been investigated in 15 EU countries, including Denmark and Sweden (Lappalainen et al., 1998). About half of the respondents in this study mentioned low fat as part of a healthy diet, followed by fruit and vegetables, balance, and variety. In the present study, the list of products ranked for healthiness only included potentially ambiguous fruits and vegetables, such as avocado which contains large amounts of healthy fat, and potatoes which contain large amounts of starch. Research shows that people tend to classify foods according to a good/bad dichotomy (Rozin et al., 1996) and that fat content is the most common category used for evaluation (Carels, Harper, & Konrad, 2006).

4.3. Priority of motives for choice, related to perceived healthiness of products

In this study, calorie-reduced dairy products were ranked as relatively healthy compared to a selection of products. Furthermore, the most highly prioritised motives for choosing these calorie-reduced products were as follows: a low fat content, keeps one healthy, nutritious (California), weight control (Denmark) and good taste (Norway). On the one hand, studies have reported that for food to be perceived as healthy and leading to weight loss it should have low fat content and be nutritious (e.g. contain vitamins, minerals and a good fat quality) (Carels et al., 2006; Carels et al., 2007; Roininen et al., 2000). On the other hand, foods high in calorie, fat or sugar content are mainly perceived as unhealthy (Carels et al., 2006; Carels et al., 2007) and often pleasure-giving. Roininen et al. (2000) found that for food to be pleasure-giving it should have sensory appeal and good taste. The concepts of health and pleasure are often seen as opposites (Lindeman & Stark, 1999), however, in our study this does not seem to be the case as particularly the Norwegian students prioritised good taste among the important motives for choosing calorie-reduced yoghurt and cheese.

4.4. Limitations

The limitations of the study must be recognised. The range of respondents' ages, as well as only including calorie-reduced dairy product consumers and university students is a limitation for general application of the findings. Furthermore, this study did not consider the effect of weight and health status of the respondents when investigating choice motives and healthiness perception of calorie-reduced dairy products. Present study used the FCQ as a basis for selecting motives. The appropriateness of the selected motives in relation to young consumers of calorie-reduced yoghurt and cheese in all countries would have been revealed by conducting focus groups. The same applies for the selection of the 15 food products used in the ranking test. Despite the fact that the consumers were required to choose motives even if they felt that none of the alternatives were

acceptable, the dual sorting test was an effective tool to access motives for consuming calorie-reduced yoghurt and cheese. The same is the case for the ranking test. By forcing the respondents to rank foods according to healthiness, the respondents had to evaluate the disadvantages and benefits of each product and give a priority. However, this does not mean the lowest ranked products were perceived as unhealthy by the respondents, just less healthy than the alternatives.

5. Conclusion

The current study was conducted in California, Denmark and Norway. It was shown that young consumers, regardless of culture, have similar motives for choice of calorie-reduced dairy products. The motive which received the highest priority was a low fat content, but the healthiness and good taste were also highly prioritised in all three countries. Another interesting result using a ranking test was that young consumers generally seem to perceive calorie-reduced dairy products, like yoghurt and cheese, as relatively healthy.

Acknowledgements

This work was part of the project “Low energy products and consumer preferences” and was financed by the Research Council of Norway (NFR) through the Grant 167928/I10. The authors would like to thank TINE BA, Norway, who allowed the use of data from the project, Dr. Hildegard Heymann for good advice and support during implementation of the study in California and Dr. Øydis Ueland for helpful comments and recommendations during the preparation of the present paper.

References

- Ajzen, I., & Fishbein, M. (1980). *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, NJ: Prentice-Hall Inc.
- Ares, G., & Gámbaro, A. (2007). Influence of gender, age and motives underlying food choice on perceived healthiness and willingness to try functional foods. *Appetite*, *49*(1), 148-158.
- Ares, G., Giménez, A., & Gámbaro, A. (2008). Understanding consumers' perception of conventional and functional yogurts using word association and hard laddering. *Food Quality and Preference*, *19*(7), 636-643.
- Axelson, M. L. (1986). The impact of culture on food-related behavior. *Annual Review of Nutrition*, *6*, 345-363.
- Brislin, R. W. (1970). Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology*, *1*(3), 185-216.
- Bruhn, C. M., Cotter, A., Diaz-Knauf, K., Sutherlin, J., West, E., Wightman, N., Williamson, E., & Yaffee, M. (1992). Consumer Attitudes and Market Potential for Dairy Products Utilizing Fat Substitutes. *Journal of Dairy Science*, *75*(9), 2569-2577.
- Brunso, K., Scholderer, J., & Grunert, K. G. (2004). Closing the gap between values and behavior - a means-end theory of lifestyle. *Journal of Business Research*, *57*(6), 665-670.
- Brunso, K., Verbeke, W., Olsen, S. O., & Jeppesen, L. F. (2009). Motives, barriers and quality evaluation in fish consumption situations: Exploring and comparing heavy and light users in Spain and Belgium. *British Food Journal*, *111*(7), 699-716.
- Carels, R. A., Harper, J., & Konrad, K. (2006). Qualitative perceptions and caloric estimations of healthy and unhealthy foods by behavioral weight loss participants. *Appetite*, *46*(2), 199-206.
- Carels, R. A., Konrad, K., & Harper, J. (2007). Individual differences in food perceptions and calorie estimation: An examination of dieting status, weight, and gender. *Appetite*, *49*(2), 450-458.
- Crossley, M. L., & Khan, S. N. (2001). Motives underlying food choice: dentists, porters and dietary health promotion. *British Dental Journal*, *191*(4), 198-202.
- Dennison, C. M., & Shepherd, R. (1995). Adolescent food choice: an application of the Theory of Planned Behavior. *Journal of Human Nutrition and Dietetics*, *8*(1), 9-23.
- Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.
- Furst, T., Connors, M., Bisogni, C. A., Sobal, J., & Falk, L. W. (1996). Food Choice: A Conceptual Model of the Process. *Appetite*, *26*(3), 247-265.
- Groth, M. V., Sørensen, M. R., Biloft-Jensen, A., Matthiessen, J., Kørup, K., & Fagt, S. (2009). *Danskernes måltidsvaner, holdninger, motivation og barrierer for at spise sundt 1995-2008*. Søborg: DTU Fødevarerinstitutionen.
- Guerrero, L., Gelabert, J., Guardia, M. D., Gou, P., Arnau, J., Shepherd, R., & Sparks, P. (1998). Consumer attitude towards low salt meat products. *Food Science and Technology International*, *4*(4), 263-275.

- Haddad, Y., Haddad, J., Olabi, A., Shuayto, N., Haddad, T., & Toufeili, I. (2007). Mapping determinants of purchase intent of concentrated yogurt (Labneh) by conjoint analysis. *Food Quality and Preference*, 18(5), 795-802.
- Hochberg, Y., & Tamhane, A. C. (1987). Distribution-Free and Robust Procedures, *Multiple Comparison Procedures*. New York, NY: John Wiley & Sons, Chap. 9, pp. 234-273.
- Honkanen, P., & Frewer, L. (2009). Russian consumers' motives for food choice. *Appetite*, 52(2), 363-371.
- Jaeger, S. R., & Rose, J. M. (2008). Stated choice experimentation, contextual influences and food choice: A case study. *Food Quality and Preference*, 19(6), 539-564.
- Johansen, S. B., Næs, T., Øyaas, J., & Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21(1), 13-21.
- Kähkönen, P., Tuorila, H., & Lawless, H. (1997). Lack of effect of taste and nutrition claims on sensory and hedonic responses to a fat-free yoghurt. *Food Quality and Preference*, 8(2), 125-130.
- La Berge, A. F. (2008). How the Ideology of Low Fat Conquered America. *Journal of the History of Medicine and Allied Sciences*, 63(2), 139-177.
- Lappalainen, R., Kearney, J., & Gibney, M. (1998). A pan EU survey of consumer attitudes to food, nutrition and health: an overview. *Food Quality and Preference*, 9(6), 467-478.
- Light, A., Heymann, H., & Holt, D. L. (1992). Hedonic Responses to Dairy-Products: Effects of Fat Levels, Label Information, and Risk Perception. *Food Technology*, 46(7), 54-57.
- Lindeman, M., & Sirelius, M. (2001). Food choice ideologies: the modern manifestations of normative and humanist views of the world. *Appetite*, 37(3), 175-184.
- Lindeman, M., & Stark, K. (1999). Pleasure, Pursuit of Health or Negotiation of Identity? Personality Correlates of Food Choice Motives Among Young and Middle-aged Women. *Appetite*, 33(1), 141-161.
- Mardia, K. V., Kent, J. T., & Bibby, J. M. (1980). *Multivariate Analysis*. London, UK: Academic Press.
- Martens, H., & Næs, T. (1989). *Multivariate Calibration*. Chichester, UK: John Wiley & Sons.
- Mela, D. J. (1999). Food choice and intake: the human factor. *Proceedings of the Nutrition Society*, 58(3), 513-521.
- Musher-Eizenman, D. R., de Lauzon-Guillain, B., Holub, S. C., Leporc, E., & Charles, M. A. (2009). Child and parent characteristics related to parental feeding practices. A cross-cultural examination in the US and France. *Appetite*, 52(1), 89-95.
- O'Mahony, M. (1986). *Sensory Evaluation of Food: Statistical Methods and Procedures*. New York, NY: Marcel Dekker Inc.
- Oakes, M. E., & Slotterback, C. S. (2001a). Gender differences in perceptions of the healthiness of foods. *Psychology and Health*, 16(1), 57-65.
- Oakes, M. E., & Slotterback, C. S. (2001b). Judgements of food healthfulness: food name stereotypes in adults over age 25. *Appetite*, 37(1), 1-8.

- Oakes, M. E., & Slotterback, C. S. (2001c). What's in a name? A comparison of men's and women's judgements about food names and their nutrient contents. *Appetite*, *36*(1), 29-40.
- Oakes, M. E., & Slotterback, C. S. (2002). The good, the bad, and the ugly: Characteristics used by young, middle-aged, and older men and women, dieters and non-dieters to judge healthfulness of foods. *Appetite*, *38*(2), 91-97.
- Pieniak, Z., Verbeke, W., Perez-Cueto, F., Brunsø, K., & De Henauw, S. (2008). Fish consumption and its motives in households with versus without self-reported medical history of CVD: A consumer survey from five European countries. *BMC Public Health*, *8*, 1-14.
- Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, *19*(8), 459-466.
- Pollard, J., Kirk, S. F. L., & Cade, J. E. (2002). Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews*, *15*(2), 373-387.
- Prescott, J., Young, O., O'Neill, L., Yau, N. J. N., & Stevens, R. (2002). Motives for food choice: a comparison of consumers from Japan, Taiwan, Malaysia and New Zealand. *Food Quality and Preference*, *13*(7), 489-495.
- Roininen, K., Lähteenmäki, L., & Tuorila, H. (1999). Quantification of Consumer Attitudes to Health and Hedonic Characteristics of Foods. *Appetite*, *33*(1), 71-88.
- Roininen, K., Lähteenmäki, L., & Tuorila, H. (2000). An application of means-end chain approach to consumers' orientation to health and hedonic characteristics of foods. *Ecology of Food and Nutrition*, *39*(1), 61-81.
- Ross, B. H., & Murphy, G. L. (1999). Food for Thought: Cross-Classification and Category Organization in a Complex Real-World Domain. *Cognitive Psychology*, *38*(4), 495-553.
- Rozin, P., Ashmore, M., & Markwith, M. (1996). Lay American Conceptions of Nutrition: Dose Insensitivity, Categorical Thinking, Contagion, and the Monotonic Mind. *Health Psychology*, *15*(6), 438-447.
- Rozin, P., Fischler, C., Imada, S., Sarubin, A., & Wrzesniewski, A. (1999). Attitudes to Food and the Role of Food in Life in the U.S.A., Japan, Flemish Belgium and France: Possible Implications for the Diet-Health Debate. *Appetite*, *33*(2), 163-180.
- Rozin, P., Kurzer, N., & Cohen, A. B. (2002). Free associations to "food:" the effects of gender, generation, and culture. *Journal of Research in Personality*, *36*(5), 419-441.
- Sharma, B., Harker, M., Harker, D., & Reinhard, K. (2009). Living independently and the impact on young adult eating behaviour in Germany. *British Food Journal*, *111*(5), 436-451.
- Shepherd, R. (1999). Social determinants of food choice. *Proceedings of the Nutrition Society*, *58*(4), 807-812.
- Siret, F. (2004). *Contribution à l'étude du concept de tradition en charcuterie cuite. Deux exemples: le jambon cuit et le paté de campagne*. Thèses de doctorat, Université de Bourgogne, Dijon, France.

- Sobal, J. (1998). Cultural comparison research designs in food, eating, and nutrition. *Food Quality and Preference*, 9(6), 385-392.
- Step toe, A., Pollard, T. M., & Wardle, J. (1995). Development of a Measure of the Motives Underlying the Selection of Food: the Food Choice Questionnaire. *Appetite*, 25(3), 267-284.
- Sulmont-Rossé, C., Issanchou, S., Enderli, G., Verbeke, W., Vanhonacker, F., Contel, M., Scalvedi, M. L., Żakowska-Biemans, S., Sajdakowska, M., Guerrero, L., Guàrdia, M. D., Granli, B. S., & Hersleth, M. (2007). Which innovations do consumers accept in traditional foods? Application of a dual sorting test, *7th Pangborn Sensory Science Symposium*. Minneapolis, USA.
- Sun, Y.-H. C. (2008). Health concern, food choice motives, and attitudes toward healthy eating: The mediating role of food choice motives. *Appetite*, 51(1), 42-49.
- Verbeke, W., Sioen, I., Pieniak, Z., Van Camp, J., & De Henauw, S. (2005). Consumer perception versus scientific evidence about health benefits and safety risks from fish consumption. *Public Health Nutrition*, 8(4), 422-429.
- Vickers, Z., & Mullan, L. (1997). Liking and consumption of fat-free and full-fat cheese. *Food Quality and Preference*, 8(2), 91-95.
- Visschers, V. H. M., & Siegrist, M. (2009). Applying the evaluability principle to nutrition table information. How reference information changes people's perception of food products. *Appetite*, 52(2), 505-512.
- Wansink, B. (2003). Response to "Measuring consumer response to food products". Sensory tests that predict consumer acceptance. *Food Quality and Preference*, 14(1), 23-26.
- Westcombe, A., & Wardle, J. (1997). Influence of Relative Fat Content Information on Responses to Three Foods. *Appetite*, 28(1), 49-62.

Table 1

Statements used in the dual sorting test, which in the yoghurt case was introduced by “Select # descriptions that are important for non- or low-fat yoghurt”, where # was a number which changed depending on the sorting step, thus 12, 6 or 3. The introduction was followed by “I choose non- or low-fat yoghurt because...” and then the screen showed twice the number of statements as the respondent was asked to select. The tested statements were based on The Food Choice Questionnaire by Steptoe, Pollard, and Wardle (1995), however, the statements in *italics* were additional statements.

Statements	Abbreviations
It contains a lot of vitamins and minerals	Vitamin & mineral
It keeps me healthy	Keeps me healthy
It is nutritious	Nutritious
It is high in protein	High in protein
<i>It suits my lifestyle</i>	Suits lifestyle
It helps me cope with stress	Cope stress
It cheers me up	Cheers up
It makes me feel good	Feel good
It takes no time to prepare	No time to prepare
It is easily available in shops and supermarkets	Available in shops
It smells nice	Smells nice
It looks nice	Looks nice
It has a pleasant texture	Pleasant texture
It tastes good	Tastes good
It contains no additives	No additives
It contains natural ingredients	Natural ingredients
It contains no artificial ingredients	No artificial ingr.
It is cheap	Cheap
It is good value for money	Value for money
It helps me control my weight	Control weight
It is low in fat	Low in fat
<i>It is low in sugar</i>	Low in sugar
It is what I usually eat	Usually eat
I have been eating this since childhood	Eating since child.

Table 2

The 15 food products in the two-step ranking test, where the respondents were asked to rank the products according to how healthy they perceive the products to be. First step was introduced by “Categorize the products with 5 products in each of the three categories ‘Most healthy’, ‘Medium healthy’ and ‘Least healthy’...”. The respondent had to drag and drop 5 products in each category to continue. Next step was product ranking within each category, thus this was repeated three times. This step was introduced by “Range the 5 products from ‘Most healthy’ to ‘Least healthy’...”.

Egg	Pasta	Avocado
Olive oil	Pork	Beer
Nuts	Non- or low-fat cheese	Milk
Salmon	Orange juice	Raisins
Potatoes	Wine	Non- or low-fat yoghurt

Table 3

Results of the dual sorting test on yoghurt. The table presents mean score, standard deviation and chi-square for all 24 statements across countries and for each country separately. Statements are sorted according to overall mean score.

Statements	All (n = 370)			California (n = 127)			Denmark (n = 125)			Norway (n = 118)		
	Mean	SD	χ^2	Mean	SD	χ^2	Mean	SD	χ^2	Mean	SD	χ^2
Low in fat	2.06	1.15	586.21**	1.72	1.20	92.10***	2.38	1.0	359.11***	2.08	1.11	186.31**
Keeps me healthy	1.78	1.08	274.18**	1.64	1.10	67.43***	1.98	1.0	145.48***	1.73	1.03	79.64***
Tastes good	1.75	1.09	257.74**	1.83	1.10	108.34**	1.63	1.0	65.69***	1.79	1.09	89.08***
Control weight	1.25	1.17	48.48***	0.97	1.16	5.90	1.55	1.1	52.66***	1.24	1.11	15.69***
Nutritious	1.15	1.12	26.34***	1.87	1.07	114.76**	0.66	0.8	9.90*	0.89	1.01	2.07
Available in shops	1.14	0.98	73.65***	1.24	0.95	45.25***	1.09	0.9	27.32***	1.08	1.04	10.64**
Suits lifestyle	1.14	1.07	42.05***	0.89	0.94	8.65*	1.42	1.1	39.10***	1.12	1.05	19.63***
Low in sugar	1.11	1.14	19.38***	0.61	0.91	8.18*	1.10	1.0	7.88*	1.66	1.19	73.36***
No time to prepare	1.10	1.05	28.90***	1.35	1.06	33.87***	1.17	1.0	18.98***	0.75	0.95	4.31
Usually eat	0.94	0.99	19.45***	0.92	0.96	9.41*	0.88	0.9	8.86*	1.01	1.07	5.53
Feel good	0.89	0.93	34.08***	0.66	0.88	7.30	1.03	0.9	21.56***	1.00	0.92	23.75***
Vitamin & mineral	0.76	0.97	5.72	0.95	1.03	3.80	0.62	0.9	7.34	0.69	0.93	4.24
High in protein	0.73	1.04	17.17***	0.95	1.13	2.80	0.67	1.0	8.60*	0.55	0.95	16.56***
Natural ingredients	0.69	0.91	14.21***	0.74	0.96	4.50	0.75	0.9	6.20	0.58	0.85	9.59*
Looks nice	0.67	0.88	20.19***	0.28	0.57	44.23***	0.66	0.7	15.14**	1.10	1.04	14.07**
Pleasant texture	0.62	0.75	50.70***	0.74	0.77	34.75***	0.58	0.7	14.87**	0.53	0.72	15.76***
Cheers up	0.59	0.79	35.26***	0.31	0.64	40.45***	0.62	0.7	18.47***	0.88	0.89	18.32***
Eating since child.	0.51	0.89	56.93***	0.84	1.09	3.20	0.34	0.6	34.74***	0.31	0.71	42.17***
Cheap	0.46	0.81	63.92***	0.61	0.85	9.28*	0.36	0.7	40.14***	0.42	0.83	29.25***
No artificial ingr.	0.45	0.77	61.24***	0.42	0.81	36.81***	0.46	0.7	19.51***	0.48	0.76	16.88***
Value for money	0.40	0.75	82.45***	0.66	0.92	6.86	0.29	0.6	46.58***	0.24	0.57	49.73***
No additives	0.36	0.69	92.44***	0.28	0.59	43.20***	0.38	0.7	32.94***	0.44	0.77	21.31***
Smells nice	0.34	0.64	101.92**	0.35	0.72	37.05***	0.26	0.5	46.28***	0.40	0.63	27.53***
Cope stress	0.10	0.39	267.55**	0.15	0.47	77.87***	0.11	0.4	88.78***	0.04	0.24	102.64**

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table 4 Results of the dual sorting test on cheese. The table presents mean score, standard deviation and chi-square for all 24 statements across countries and for each country separately. Statements are sorted according to overall mean score.

Statements	All (n = 370)		California (n = 127)		Denmark (n = 125)		Norway (n = 118)	
	Mean	SD	χ^2	Mean	SD	χ^2	Mean	SD
Low in fat	2.17	1.07	669.07***	1.91	1.08	125.47***	2.30	1.06
Keeps me healthy	1.89	1.08	348.03***	1.89	1.10	122.18***	1.92	1.10
Tastes good	1.59	1.10	179.90***	1.63	1.13	68.84***	1.54	1.04
Control weight	1.39	1.21	99.43***	1.16	1.21	13.63**	1.62	1.19
Nutritious	1.19	1.12	35.17***	1.90	1.10	125.79***	0.75	0.98
Available in shops	1.17	0.98	82.04***	1.24	1.00	32.01***	1.17	0.98
Suits lifestyle	1.13	1.01	53.52***	0.85	0.86	22.13***	1.33	1.05
Feel good	1.02	0.98	42.30***	0.77	0.91	6.17	1.28	0.95
No time to prepare	0.98	1.04	11.98**	1.35	1.07	31.85***	0.98	1.03
Low in sugar	0.95	1.08	3.25	0.54	0.82	12.95**	1.05	1.13
Usually eat	0.92	0.96	33.68***	0.79	0.96	3.38	1.00	0.93
High in protein	0.82	1.03	1.31	1.04	1.07	7.30	0.71	1.00
Vitamin & mineral	0.69	0.89	17.14***	0.77	0.89	8.04*	0.60	0.89
Natural ingredients	0.66	0.87	21.97***	0.68	0.83	15.27**	0.66	0.92
Pleasant texture	0.65	0.82	34.65***	0.70	0.83	12.23**	0.71	0.85
Looks nice	0.59	0.83	29.90***	0.26	0.58	49.38***	0.62	0.76
Chers up	0.59	0.83	30.11***	0.38	0.77	33.65***	0.52	0.68
No artificial ingr.	0.47	0.84	63.50***	0.40	0.79	32.01***	0.40	0.79
Eating since child.	0.47	0.86	68.86***	0.79	1.06	2.28	0.42	0.76
Cheap	0.44	0.81	75.46***	0.53	0.89	22.45***	0.38	0.72
No additives	0.42	0.79	83.35***	0.35	0.69	35.68***	0.39	0.79
Value for money	0.37	0.69	89.47***	0.59	0.83	10.92**	0.26	0.58
Smells nice	0.32	0.62	109.08***	0.28	0.55	41.72***	0.33	0.58
Cope stress	0.10	0.43	277.03***	0.21	0.61	68.28***	0.05	0.31

* $p > 0.05$; ** $p > 0.01$; *** $p < 0.001$.

Table 5

Nominal logistic regression on the dual sorting data for yoghurt and cheese for all the countries. The table presents p -values of the overall models and for the difference between genders.

Statements	Overall model p -value	Female vs. male	
		Yoghurt	Cheese
Low in fat	0.00	0.00 (+)	0.01 (+)
Keeps me healthy	0.00	ns	0.03 (+)
Control weight	0.00	0.00 (+)	0.00 (+)
Vitamin & mineral	0.05	0.01 (-)	ns
Natural ingredients	0.06	ns	0.01 (-)
No artificial ingr.	0.01	0.01 (-)	ns

(+): larger response from females, (-): smaller response from females and ns: non-significant.

Table 6

Friedman Two-Way Analysis of Variance for the product ranking in California, Denmark and Norway.

California (n=127)		Denmark (n=125)		Norway (n=118)	
Friedman Test	Kendall Coefficient of Concordance = 0.416 ^a	Friedman Test	Kendall Coefficient of Concordance = 0.396 ^a	Friedman Test	Kendall Coefficient of Concordance = 0.463 ^a
Rank sum	Tukey's HSD test	Rank sum	Tukey's HSD test	Rank sum	Tukey's HSD test
1550	1308.3	1480	1240.0	1607	1374.0
Salmon	a	Salmon	a	Salmon	a
Yoghurt [†]	1235.3	1477	1096.0	1241	1008.0
Yoghurt [†]	a b	Yoghurt [†]	a b	Avocado	a b
Milk	1294	1052.3	1311	1071.0	1169
Milk	b c	Milk	a b	Egg	b c
Orange juice	1267	1025.3	1285	1045.0	1149
Orange juice	b c d	Avocado	a b	Yoghurt [†]	b c
Nuts	1214	972.3	1202	962.0	1130
Nuts	c d	Nuts	b c	Olive oil	b c
Raisins	1163	921.3	1169	929.0	1114
Raisins	c d	Potatoes	b c d	Nuts	b c
Avocado	1112	870.3	1119	879.0	1042
Avocado	c d	Chese [†]	b c d	Chese [†]	b c d
Chese [†]	1111	869.3	1006	766.0	1017
Chese [†]	c d	Raisins	c d e	Orange juice	b c d e
Egg	1110	868.3	1005	765.0	1014
Egg	c d	Orange juice	c d e	Milk	b c d e
Olive oil	1046	804.3	981	741.0	943
Olive oil	d	Olive oil	c d e	Pork	c d e
Potatoes	749	507.3	945	705.0	832
Potatoes	e	Egg	d e	Raisins	d e
Pasta	724	482.3	803	563.0	791
Pasta	e	Pork	e	Potatoes	e
Wine	674	432.3	774	534.0	487
Wine	e	Pasta	e	Pasta	f
Pork	539	297.3	420	180.0	480
Pork	e	Wine	f	Wine	f
Beer	210	-31.7	164	-76.0	144
Beer	f	Beer	f	Beer	g

^a Probability is 0.000 assuming Chi-square distribution with 14 df. For the columns with Tukey's Honestly Significant Differences test different letters indicate significant difference at a 5% level. [†] Non-fat or low-fat.

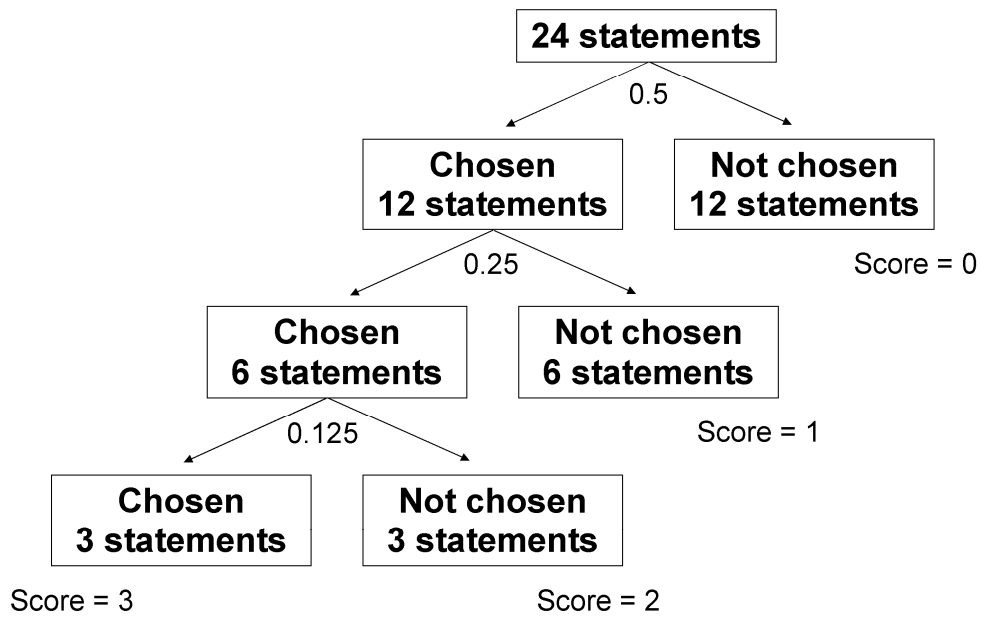


Fig. 1. Principle of the dual sorting test. In the yoghurt case the motives were introduced by “Select # descriptions that are important for non- or low-fat yoghurt”. # was 12, 6 or 3, respectively. The introduction was followed by “I choose non- or low-fat yoghurt because...” and the respondent had to choose the stated number of statements. The statements tested can be seen in Table 1.

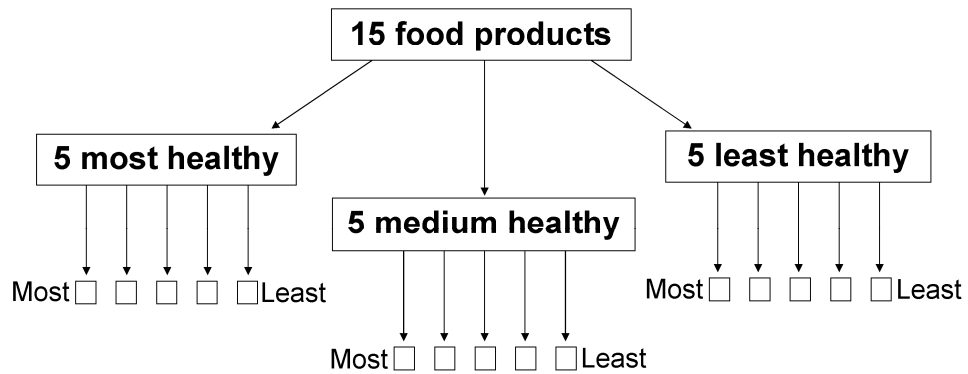


Fig. 2. Principle of the product ranking test. The test was introduced by “Categorize the products with 5 products in each of the three categories “Most healthy”, “Medium healthy” and “Least healthy”...”. This introduction was followed by “Drag the products you choose into the frames...” and the screen showed 15 product names and three category frames in which the products should be placed. The 15 products tested can be seen in Table 2.

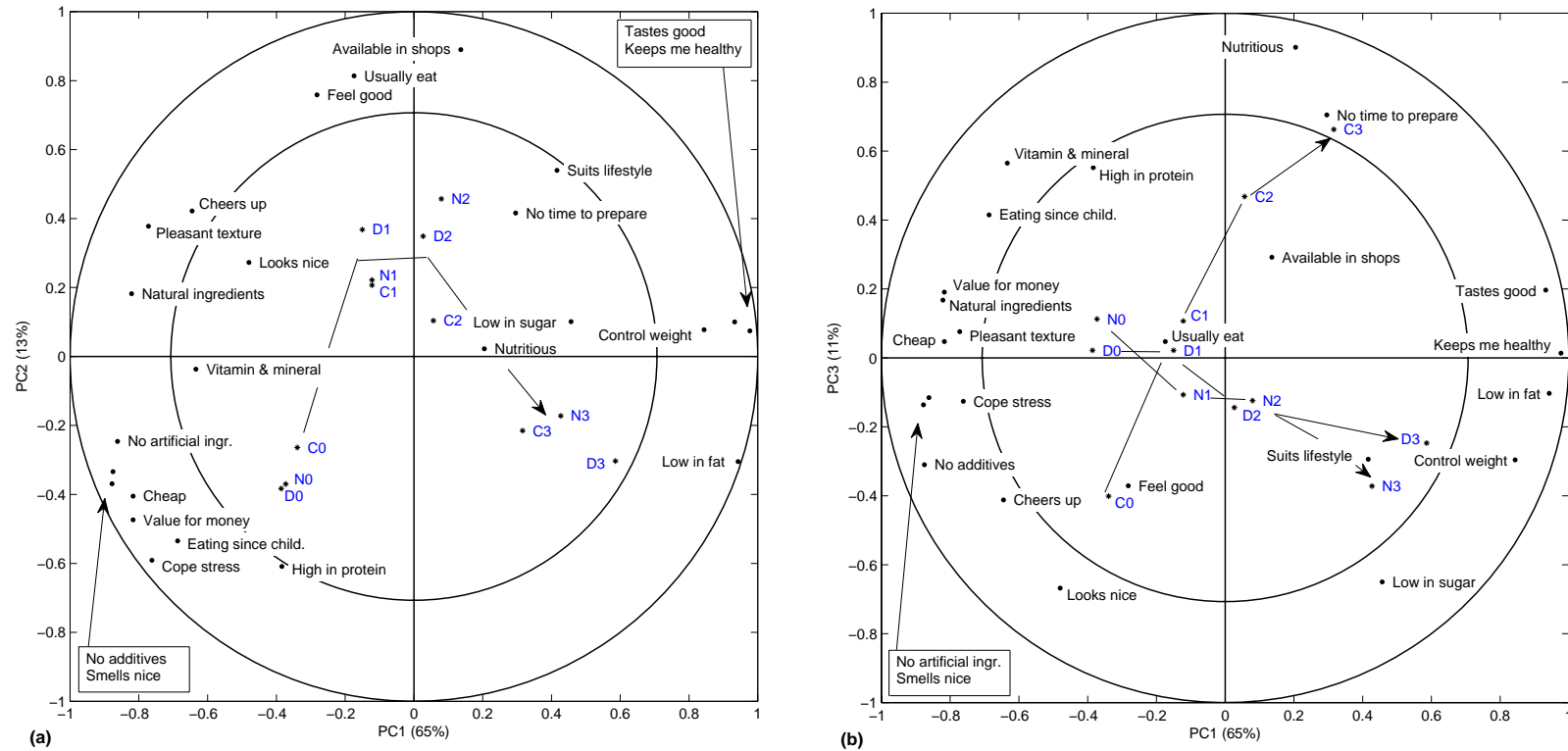


Fig. 3. PCA correlation loadings plot showing the correlations between each of the countries sorting category and the motives for choosing calorie-reduced yoghurt: (a) shows first and second principal components while (b) shows first and third principal components, respectively. The variables were centred, not standardized and full cross-validation was applied. The direction of increasing sorting category is shown for each country. The countries are denoted by C = California, D = Denmark, N = Norway. The sorting categories are denoted by 0 = not selected at first step, 1 = not selected at second step, 2 = not selected at third step and 3 = selected at the third step. The inner and outer circle indicates 50% and 100% explained variance, respectively.

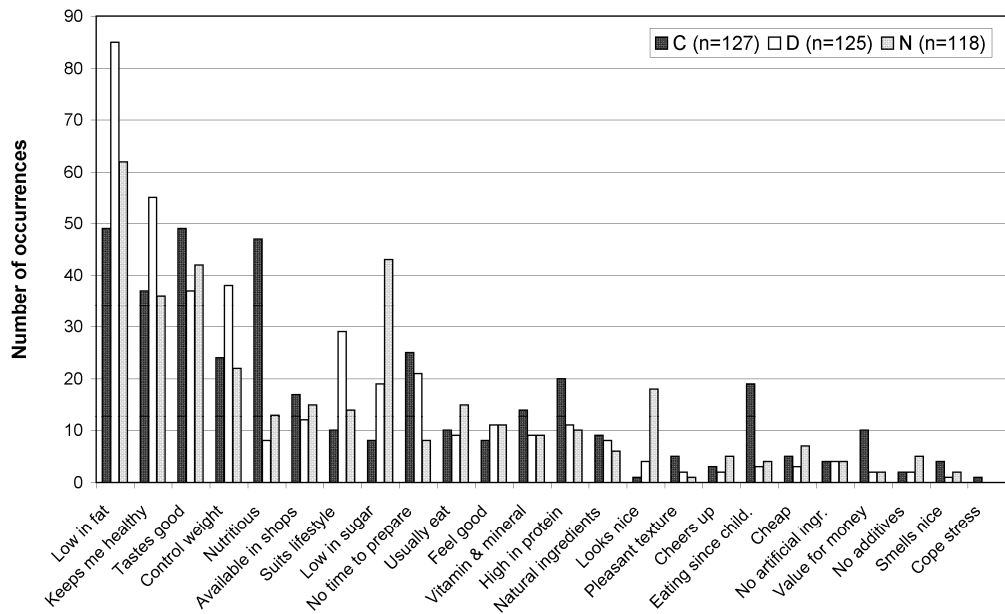


Fig. 4. Number of times a statement was sorted as being one of the three main motives for consuming calorie-reduced yoghurt. The countries are denoted by C = California, D = Denmark, N = Norway.

Paper II



Contents lists available at ScienceDirect

Food Quality and Preference

journal homepage: www.elsevier.com/locate/foodqual

A new approach to product set selection and segmentation in preference mapping

Susanne Bølling Johansen^{a,b,*}, Margrethe Hersleth^{a,b}, Tormod Næs^{a,c}^a Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway^b Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway^c Department of Mathematics, University of Oslo, P.O. Box 1053, Blindern, NO-0316 Oslo, Norway

ARTICLE INFO

Article history:

Received 31 October 2008

Received in revised form 26 May 2009

Accepted 26 May 2009

Available online 2 June 2009

Keywords:

Fuzzy clustering

FCM

Segmentation

Ideal point preference mapping

Low-fat cheese

ABSTRACT

A common problem in food product development is to identify the consumers' drivers of liking and to understand in what way they relate to the acceptance data. Usually, one will also be interested in identifying segments of consumers. The main objective of this study was to investigate the use of fuzzy clustering within the area of preference mapping when different consumer groups test different sets of products. A case study on low-fat cheese was used to explore and illustrate the proposed approach. Two groups of 57 and 58 consumers, respectively, participated in the consumer test. Based on sensory profiling, different cheese products evenly distributed in the sensory space were selected for each group. Each consumer rated their acceptance based on a blind tasting of six cheeses. One of the segments was identified to have a linear preference pattern, while the other two had non-linear patterns.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

A common problem in product development is to identify the drivers of liking in the actual market (Gambaro, Ares, Gimenez, & Pahor, 2007; Green & Srinivasan, 1978; Gustafsson, Herrmann, & Huber, 2003; McEwen, 1996). In most cases, one will also be interested in identifying the segments of consumers with similar preference patterns, and a number of techniques have been put forward for this purpose, based on various types of cluster analysis (Wedel & Kamakura, 1998; Wedel & Steenkamp, 1989, 1991). These methods can be used in both a preference mapping context and in a conjoint analysis context (Næs, Kubberød, & Sivertsen, 2001), although in this paper the focus will be on preference mapping applications.

Preference mapping is based on relating sensory profile data to individual consumer preference data using statistical regression methods such as principal component regression (PCR) and partial least squares regression (PLSR) and then presenting the results graphically in maps (Schlich & McEwan, 1992). A major problem when using these methods, in particular for non-linear ideal points models (McEwen, 1996), is the trade-off that has to be made between the statistical need for as many tested products as possible and the practical limitation related to how many products a consumer can actually test. Many products give precise model esti-

mates, but too many products may produce consumer fatigue which makes the experimental setup more tedious. Analyzing all consumers in the same model may be a possible solution, but this would mean that one only focuses on the average liking, which is generally not recommended. In many cases, segmentation is therefore the most natural approach, representing a type of compromise between individual modelling and a joint approach, while at the same time providing information about possible group patterns in the data sets.

In this paper, we will consider an approach to segmentation within preference mapping based on both a new way of selecting products to consumers, and in the use of fuzzy cluster analysis (FCM) by using regression distance to analyse the data. This new way of selecting products allows for the selection of different products for different consumers and also to represent the product space of sensory interest as evenly as possible. In our case study, we consider two groups of consumers testing two different sets of products. The fuzzy clustering method, with the use of the residual distance, allows for analyzing this type of data, since only the residual between the preference value and the model for the preference value is used in the clustering. For references to this approach, in both theoretical aspects and applications within consumer science, we refer to Berget, Mevik, and Næs (2008), Næs and Isaksson (1991) and Wedel and Steenkamp (1989, 1991). Using fuzzy clustering also has other advantages related to membership values, flexibility and good convergence properties as will be discussed below. This method has previously been used for conjoint studies, but as far as we know not for preference mapping. A case study on low-fat cheese will be used to explore and

* Corresponding author. Address: Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway. Tel.: +47 64 970482; fax: +47 64 970333.

E-mail address: susanne.johansen@nofima.no (S.B. Johansen).

illustrate the proposed approach. The primary purpose of this case study was to gain an improved understanding of the Norwegian consumers' preference for low-fat cheese, and to identify possible consumer segments.

2. Selection of products for different consumer groups

In this paper, it is assumed that an initial set of products that represents all products of interest are available (Helgesen, Solheim, & Næs, 1997). In this case, this group of products represents the entire market of the cheese type studied. It will also be assumed that the sensory data is available for this initial group of products.

In order to provide as much information as possible from each consumer and to avoid consumer segments based on only one part of the sensory region, each consumer is given products that cover the entire principal component analysis (PCA) score plot (based on sensory analysis) as evenly as possible (usually in two dimensions). This product selection criterion is important for several reasons (Næs & Isaksson, 1991), and should be used regardless of whether the data is meant for linear or ideal point preference mapping. First of all, covering the entire area, even for products close to the border, is important for getting the best possible precision from the estimates. Secondly, the even spread of the products ensures that all parts of the region are represented, thereby providing good opportunities for checking model quality. A third argument that was put forward in Zemroch (1986), and Næs and Isaksson (1991), is that this type of product selection is robust in the sense that it will produce reasonable models, even in cases where the model assumptions are not totally correct. For example, even if the true relation is slightly non-linear, the predicted values from the model are reasonably good even if a linear model is fitted. When different products are tested by different consumers, one should make sure that each set of products covers the sensory regions as evenly as possible. This means, for instance, that one should avoid products from one group of products that are too close to each other.

There are different ways of conducting product selection using these criteria, based on either a simple visual selection directly from the PCA score plot or based on strategies using some type of statistical cluster analysis. If the first two or three components represent most of the sensory variability (which is usually the case), the PCA selection is just as good as the one that is assisted by statistical clustering. PCA selection also provides the possibility for freely choosing products that satisfy other requirements, than just an even spread. In this case study, the PCA approach was used because products of special interest had to be part of the study.

If a more "formal" procedure is wanted, one can follow the procedure proposed by Næs and Isaksson (1991). This procedure is based on first performing a cluster analysis for all the products (sensory attributes). The clustering is stopped when the number of clusters is identical to the number of products that can be presented to each consumer, such as six in this case. One product is then selected from each cluster for each consumer. For related work, we refer to Riviere, Monrozier, Rogeaux, Pages, and Saporta (2006).

3. Segmentation and model fitting methods

In most case studies of this type, the sensory variables are strongly collinear (Martens & Næs, 1989), and one needs to use regression methods that can handle this type of problem. One possible way of solving the problem is to compress the data by using PCA prior to regression or cluster analysis (Martens & Næs, 1989; McEwen, 1996). For regular linear preference mapping, both PCR

and PLS can be used, but for ideal point mapping the most natural approach is based on polynomial PCR.

3.1. The ideal point model

The ideal point model to be used for each of the consumers here will be the second degree polynomial based on two principal components, i.e.

$$y = \beta_0 + \beta_1 t_1 + \beta_2 t_2 + \beta_3 t_1^2 + \beta_4 t_2^2 + \beta_5 t_1 t_2 + e \quad (1)$$

where the y is the preference value, β_0 is the intercept, the β 's are the regression coefficients, the t 's are the two first principal components of the sensory data, and e is the random error. As can be noted, the standard linear preference mapping PCR model is a special case obtained by setting the last three regression coefficients equal to zero. In each of the clusters found later in this paper, we will use analysis of variance in order to test for the importance of the square terms and interaction term in model (1). Note that although model (1) handles non-linear relations between the principal components and y , it is essentially a linear model which can be handled by using regular linear regression analysis.

In order to reduce the number of parameters in the model, different simplifications have been proposed (McEwen, 1996). One is based on deleting the interaction term (elliptic model) and the other is based on setting the coefficients for the quadratic terms equal to the same value (circular model). These modifications may be useful when model (1) is used for the fitting of individual acceptance data, but when used in clustering as is done here, this type of reduction has little effect on the ratio between the number of observations and the number of parameters. As will be seen below, the general structure of model (1) was important for capturing the full structure of the segments in the case study.

3.2. The proposed method based on fuzzy clustering (FCM)

The FCM approach, based on residual distance to be used here, is essentially the same method as the approach used in Wedel and Steenkamp (1989), Wedel and Steenkamp (1991), Næs and Isaksson (1991), and Næs et al. (2001), but the context is different. Other related approaches are latent class mixture models based on residuals and the more sophisticated approach which incorporates random individual regression coefficients for each consumer within each segment (Gustafsson et al., 2003).

The FCM is general in nature, and can be used for a large number of distances that measure the distance between objects and segments. The general criterion used and which is to be minimized is the following:

$$J = \sum_{j=1}^C \sum_{i=1}^N u_{ij}^m d_{ij}^2, \quad m \geq 1 \quad (2)$$

where the d 's are the distance between objects i and segments j , and the u_{ij} 's are the corresponding membership values. The C and N are the number of segments and the number of observations, respectively. The u 's can be interpreted as the degree of membership for each individual to each of the segments, and can be very useful for the interpretation of the degree of clustering in the data. The m is the fuzzifier parameter to be determined by the user. The most common value to use for m is 2 (Berget et al., 2008; Bezdec, 1981; Zahid, Limouri, & Essaid, 1999), but in the present paper another value is chosen based on a study of the properties of the solution found. Since fuzzy clustering has better convergence properties than K -means clustering (Rousseeuw, 1995), which essentially corresponds to m equal to 1 in model (2), only values large than 1 were tested. The general algorithm for solving this is simple and based on iteration between two independent steps, one optimizing u and the

other optimizing d . The algorithm has generally good convergence properties for many types of distance measures used (Berget et al., 2008; Bezdec, 1981).

The FCM method is important for many purposes and with many different types of distances, but in the present paper the focus will be on the residual distance between objects and segments (Wedel & Steenkamp, 1989, 1991). The residual distance is obtained by comparing the true acceptance value with the fitted value from a regression equation in the principal components (and their squares) of the sensory data. The idea is that segments of consumers who have a similar acceptance pattern will have the same relation between \mathbf{x} and y . The general criterion in model (2) can then be presented as

$$J = \sum_{j=1}^C \sum_{i=1}^N (u_{ij})^m (y_i - \mathbf{x}_i^T \mathbf{b}_j)^2 \quad (3)$$

where the \mathbf{b} 's are the regression coefficients for the different segments. In our special case of ideal point modelling, the vector \mathbf{x} is the vector defined by $(1, t_1, t_2, t_1^2, t_2^2, t_1 t_2)$ and \mathbf{b} is the vector of the corresponding regression coefficients (see model (1)). We refer to the papers by Wedel and Steenkamp (1989), Wedel and Steenkamp (1991), and Næs and Isaksson (1991) for further information about the properties and optimization of the FCM method.

After convergence, the algorithm provides a suggested splitting of objects into subgroups, indicated by the membership values (the u 's) and also regression coefficients \mathbf{b} within each group. This means that the method provides information about both the degree of membership to the different clusters and to the regression coefficients that define how the principal components of the sensory data influence the liking in the different segments. For segmentation purposes, the different consumers are placed in the cluster for which they have the largest membership value. The regression coefficients can be used directly as the models for the segment. For instance, these can be represented by contour plots as will be shown in the case study. If so desired, the stationary points of the models (max., min. or saddle point) can be obtained by using the standard optimization procedure. The stationary point can be plotted within the sensory map, together with the contours.

As can be noted, the residual distance is only dependent on the difference between the measured value and the function of the principal components. Therefore, it is essentially independent of the values of the t 's. If two consumers have the same pattern, this will be visible in the residuals without requiring that the two consumers have the same scores values, i.e. it is not necessary that they test the same products. Also note that this approach does not require that the same number of products be used for each consumer. These aspects are essential here, since the selection of products to be discussed is based on giving different products to different consumers. Note that standard regular cluster analysis requires that the vectors are comparable, which is not the case if the products are different, and can therefore not be used here. For more discussion of this advantage, see Næs and Isaksson (1991), Wedel and Steenkamp (1989), and Wedel and Steenkamp (1991).

4. The case study

The focus of the case study was to characterize the Norwegian low-fat cheese market, and to detect possible sensory properties that are important drivers of liking or disliking for different consumer groups.

The study consisted of two parts: a descriptive sensory analysis of 17 semi-hard, low-fat cheese products that were considered to be representative for the market of interest, and a consumer test with 12 of the cheeses, in which each consumer tasted only six.

The original 17 low-fat cheeses (from 5% to 17% fat content) were either experimentally produced or commercially available in Finland, Sweden or Norway (see Table 1). This relatively large variation in fat content (from 5% to 17%) is within the normal range for low-fat cheese sold on the Scandinavia market. All material used for each cheese product came from the same production batch, and was therefore treated as homogeneous in the statistical analysis.

The product selection procedure described in Section 2 was used to select two sets of products, each of the sets containing six products each, which was considered a manageable number for each of the consumers. The overall group of consumers was randomly split in two, with one group testing one of the product sets (consumer group 1), and the second group testing the other product sets (consumer group 2). Each consumer was asked about his or her acceptance of the six products tested. This resulted in two data sets being analyzed by the FCM, namely one data table containing the sensory attribute values for all 12 products, and one data set containing preference values for the same 12 products. The FCM method matches the two by pairing each measured acceptance value with the corresponding principal components of the sensory properties of the actual product.

4.1. Descriptive sensory analysis

A trained panel of 11 assessors performed sensory profiling according to "Generic Descriptive Analysis" as described by Lawless and Heymann (1999). The assessors were tested, selected and trained according to ISO standards (ISO, 1993), and the sensory laboratory used followed the ISO standards (ISO, 1988). The assessors agreed upon 30 attributes describing the variation of the cheese variants (the significant sensory attributes can be seen in Fig. 1). All attributes were evaluated on an unstructured line scale with labelled endpoints going from no intensity (value 1.0) at the left side to high intensity (value 9.0) at the right side. In a pre-test session, the assessors were trained in the use of the scale by testing products that were considered to be extreme for the selected attributes which are typical for the low-fat cheeses tested (products 1 and 6). The cheese products were served at a temperature of 17 °C in pieces of 50 g each. The assessors evaluated the products at an individual pace using a computerized system for the direct recording of data (CSA Compusense v 5.24, Canada). Two replicates were performed by each assessor for each cheese product. All products and replicates were served in a randomized way.

The descriptive sensory data was analyzed using both univariate (Statistix v 8.1, Analytical Software, US) and multivariate data

Table 1
Semi-hard cheese products tested in the case study.

Product no.	Fat content (%)	Country of origin	Product set no.
1	16	Norway	2
2	16	Norway	1
3	13	Norway	2
4	16	Norway	
5	10	Norway	2
6	17	Sweden	2
7	15	Finland	1
8	5	Sweden	2
9	17	Finland	2
10	17	Finland	
11	17	Sweden	
12	5	Sweden	1
13	10	Sweden	1
14	10	Sweden	
15	17	Sweden	1
16	10	Sweden	1
17	17	Sweden	

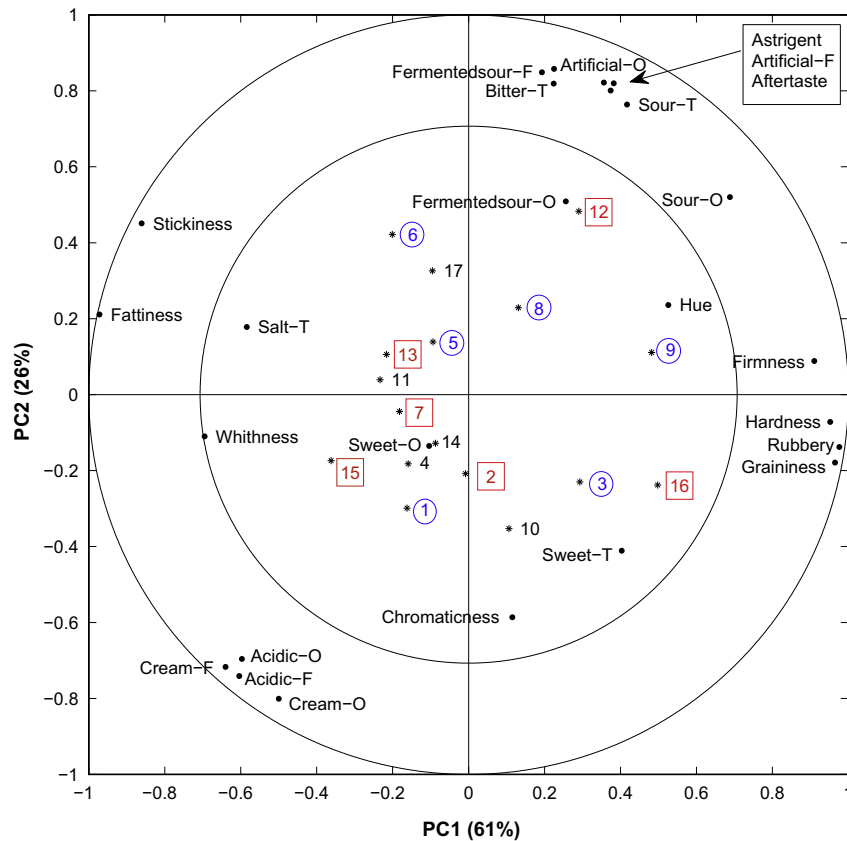


Fig. 1. PCA correlation loadings plot for the two first dimensions showing the significant sensory attributes ($p < 0.05$) for the 17 cheese products. (*) Products and (•) sensory attributes. Attributes with additional character O, F or T are the panel's evaluation of odour, flavour of taste, respectively. Cheese chosen for product set 1 is marked with a square and cheese chosen for product set 2 is marked with a circle.

analysis (The Unscrambler v 9.2, Camo AS, Norway). Analyses of variance (ANOVA, mixed model with interactions and with assessor effect and interactions considered to be random) were performed in order to identify the sensory attributes that were differentiated between products. Based on a Tukey HSD All-Pairwise Comparisons test, all sensory attributes were found to be significant except *nutty odour*, *nutty flavour*, *sun odour*, *sun flavour* and *metallic flavour*. These five non-significant sensory attributes were not included in the further data analyses.

4.2. Selection of products for consumer study

The primary choice criterion for the selection of products was intended to cover the entire experimental region as evenly as possible. It was decided that six products were the highest number of products that could be presented to each of the consumers in a single session. Two product sets were created, but other possibilities also exist. The most extreme possibility is to let all the consumers test a different set which satisfies the above criteria, but this is much more difficult to handle from a logistical point of view. The company behind the study wanted specific products (products 1, 2, 3, and 5) to be part of the study, and in addition, both sets of products had to generally have all fat levels represented. The different product sets were tested by two different groups of consumers. Consumers were randomly selected to one of the two groups. Having relatively large consumer groups makes it likely that consumers from both groups will be represented within each of the clusters, thus ensuring that each cluster represents the whole region in a dense way.

For the purpose of selecting 12 cheese products for the consumer test, a PCA of the average response over replicates and

assessors (significant attributes, $p < 0.05$) was performed (mean centred data, no standardization) (Mardia, Kent, & Bibby, 1980). Full cross-validation (Martens & Næs, 1989) was used for validation of the components.

4.3. Consumer testing

The test included 115 consumers who met the following criteria: consumers of hard or semi-hard cheese, 25–50 years of age, residing in the eastern part of Norway and interested in health issues.

The test consisted of a hedonic evaluation of products without additional information given, i.e. the consumers were told that they were participating in a cheese test, not that it was low-fat cheese. The hedonic evaluations rated the degree of liking on a modified version of the nine point hedonic scale by Peryam and Pilgrim (1957). The modified scale was anchored with “Dislike Extremely” and “Like Extremely” and with a neutral centre point of “Neither Like nor Dislike”. The cheese products were served in an order which used a balanced design (Earthy, MacFie, & Hedderley, 1997; MacFie, Bratchell, Greenhoff, & Vallis, 1989). When they finished, each of the consumers received a gift card.

4.4. Statistical methods used

A PCA was performed on the sensory data for the purpose of products set selection and also for the purpose of providing input data for the regression. In addition, a PCA was used on the consumer data in order to obtain information about the dimensionality of the consumer acceptance.

In this paper, main attention is given to the use of fuzzy clustering by the use of the residual distance. The model used in the regression is the model (1) shown above. For each product and consumer combination, the actual principal components values were paired with the true acceptance value for that combination. The fuzzifier m was determined in order to minimize the average residual values within each cluster. To a large extent, the selection of the number of segments is a subjective matter, since one can seldom expect to find well separated segments. In this paper, focus was given to three clusters, but the 3 segments' solution was also compared to the 2 and 4 segments' solutions for validation purposes. The convergence of the procedure was tested, based on using a different starting point and comparing the solutions. The calculations were done using self made software in SAS-IML (SAS v 9.1.3, SAS Institute Inc., US).

The structure of each cluster was investigated using contour plots (MATLAB v 7.7, The MathWorks, Inc., US). For each segment obtained, an analysis of variance was used to investigate the significance of the various terms in the quadratic polynomial model.

5. Results and discussion

5.1. Analysis of descriptive sensory data

Fig. 1 shows the correlation loadings plot for PCA of the significant sensory descriptive data from the 17 cheese products. The products were included as dummy variables, i.e. pacified in the data matrix of the PCA to improve the visual interpretation as suggested in Martens and Martens (2001). The first two principal components accounted for approximately 87% of the variation (61% and 26%), while the third component accounted for 6% of the variation in the data; caution should thus be taken, in both the emphasis as well as the interpretation of this component. All three components were significant according to full cross-validation.

As can be seen from the plot, the products are evenly scattered and not clustered in relation to fat content, as product 11 (17% fat content) and product 13 (10% fat content) are close together, while product 9 (17% fat content) and product 15 (17% fat content) are far from each other. The correlation coefficient between fat content and the first component score was 0.29, and between fat content and the second component score it was 0.56. The first principal component primarily describes the variation in texture and paleness, going from the firm, rubbery and less pale cheeses (products 9 and 16), to the softer, fattier and more pale cheeses (products 11, 13 and 15). The second component mainly describes the variation in odour, flavour and taste, with generally positively perceived cheese attributes such as cream and acidic flavour on one side (products 1 and 10), with the more negative cheese attributes such as fermented sour flavour and bitter taste (products 6 and 12) on the other side.

5.2. Product selection for the consumer test

The product selection for the consumer study was mainly based on the spread of the products in the first and second dimension (see Fig. 1), but as mentioned, other criteria also had to be fulfilled (see Section 4.2). In Fig. 1, the cheese products selected for each of the two consumer groups are shown. The six cheese products selected for consumer group 1 were as followed: 2 (16% fat content), 7 (15% fat content), 12 (5% fat content), 13 (10% fat content), 15 (17% fat content), 16 (10% fat content), while consumer group 2 tasted the following cheese products: 1 (16% fat content), 3 (13% fat content), 5 (10% fat content), 6 (17% fat content), 8 (5% fat content), 9 (17% fat content). As can be seen, each group received products from the entire low-fat range (from

5% to 17% fat content). In addition, the sensory region was well covered by both product sets.

5.3. Segmentation

In the following, we will give the primary attention to two principal components in the model. The main reason for this is that an initial PCA (internal preference mapping) of the two consumer groups indicated that the preference space was mainly two-dimensional, as the validated explained variance did not increase beyond two components.

5.3.1. Choice of the fuzzifier m

The first aspect tested was the choice of the fuzzifying parameter m . This was done by calculating the average absolute residual for all observations in the data set. Several values of m between 1.1 and 2.2 were tested. The value of $m = 2.0$ is often used (Berget et al., 2008; Bezdec, 1981; Zahid et al., 1999), but there is evidence for sometimes choosing otherwise. The results are presented in Table 2. An overall assessment of the different results indicated that $m = 1.1$ gives the results with the best fit, but the values of $m = 1.2$ and $m = 1.3$ gave results which were very similar. For the purpose of the rest of this paper, we used the value $m = 1.1$ for all the calculations.

As illustrated in Fig. 2, the best value of the average absolute residuals drops strongly from two to three clusters, the drop from

Table 2

Choice of m in the two principal component situations. The mean absolute residual value before segmentation is equal to 1.667.

m	2 Segments (C_2)	3 Segments (C_3)	4 Segments (C_4)	5 Segments (C_5)
1.1	1.481	1.356	1.286	1.236
1.2	1.481	1.359	1.288	1.232
1.3	1.483	1.363	1.288	1.231
1.4	1.487	1.368	1.287	1.235
1.6	1.488	1.373	1.305	1.246
1.8	1.488	1.363	1.290	1.253
2.0	1.488	1.379	1.372	1.354
2.2	1.485	1.447	1.405	1.372

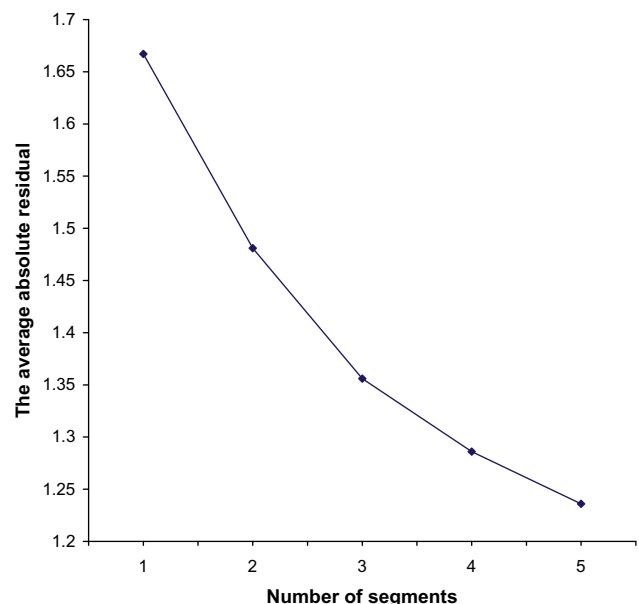


Fig. 2. The value of the average absolute residuals plotted against number of segments.

three to four becomes smaller, and the drop from four to five is smaller still. We therefore decided to concentrate on the solution with three segments. As can be seen from Table 3, the number of consumers is quite evenly spread among the three clusters, which means that there is enough information within each cluster to support model (1). In order to gain some insight into the dependence of the conclusions of this choice, some attention was also given to the solutions with two and four clusters.

The stability of the FCM algorithm (for fuzzifier $m = 1.1$ and for $C = 2$, $C = 3$ and $C = 4$ clusters) was studied by using different starting values (i.e. membership values u_{ij} 's). Many of the solutions gave identical results to those presented, but a few gave somewhat different results. The user is encouraged to test out different starting points and select a solution that represents the smallest criterion value. The algorithm converged after a limited number of iterations, typically less than 50.

The solutions presented are those which correspond to the lowest value of the average absolute residuals (i.e. the best results). In situations where different solutions were obtained, they were compared using contour plots, with much of the same tendency found for these solutions as for the one presented (more below). Some of the consumers changed segments, but the general structure of the clusters was similar.

Looking at the number of individuals from the two consumer groups within each cluster, we found that for the two cluster ($C_2 = 1$, $n_1 = 19$, $n_2 = 28$; $C_2 = 2$, $n_1 = 32$, $n_2 = 36$) and the three cluster ($C_3 = 1$, $n_1 = 27$, $n_2 = 11$; $C_3 = 2$, $n_1 = 11$, $n_2 = 19$; $C_3 = 3$, $n_1 = 21$, $n_2 = 17$) solutions, the individuals from each group were relatively evenly distributed within the clusters. However, especially for the second cluster in the four cluster solution ($C_4 = 1$, $n_1 = 20$, $n_2 = 17$; $C_4 = 2$, $n_1 = 6$, $n_2 = 19$; $C_4 = 3$, $n_1 = 18$, $n_2 = 12$; $C_4 = 4$, $n_1 = 15$, $n_2 = 8$), this was not the case.

5.3.2. Results for 2PC's and 3 segments

The analyses of variance for the solution are given in Table 3. For the first segment ($C_3 = 1$, $n = 47$), both the linear and the quadratic terms are significant, while the effect of the cross-product is not. For the next segment ($C_3 = 2$, $n = 30$), both principal components and the cross-product are significant. For the last segment ($C_3 = 3$, $n = 38$), only the first principal component is clearly significant (with the cross-product only slightly significant at the 5% level), indicating a model which is close to linear with the path of steeped ascent/descent in the direction of the first component. The R^2 's for the three segments are 0.18, 0.24 and 0.41, respectively. Table 3 shows the number of individuals from each consumer group that make up each cluster, and as can be seen, these numbers of consumers are quite comparable for all three clusters. Significant quadratic regression was seen for two ($C_3 = 1$ and 2) of the three clusters, which indicates that more

than half of the consumers are members of clusters with a non-linear relation between the principal components and the acceptance values.

The contour plots from each of the three clusters in the two component situation are visualized from Figs. 3–5. The average score of the consumer clusters is shown, and as can be seen, they fit the models well. The figures show that one of the clusters is rather linear, while the other two are non-linear.

Fig. 3 shows that the first cluster ($C_3 = 1$, $n = 47$) has a global preference maxima, in which product 1 (16% fat content), product 2 (16% fat content) and roughly product 7 (15% fat content) are all located. These three cheese products can be described as relatively fatty, soft and pale with some cream odour, cream flavour, acidic odour and acidic flavour. On average, the liking scores for the first product set ranged from 5.1 to 7.4 (2.3), and the scores for the other product set ranged from 5.9 to 7.7 (1.8). This may indicate that the consumers in this cluster generally liked all the low-fat cheese products. This is interesting since the consumers were only told that they were about to taste cheese, but not low-fat cheese. The difference in the average scoring between the two sets is very similar. It seems that this cluster ($C_3 = 1$) represents consumers who are quite satisfied with three of these particular low-fat cheeses, and in total they give quite high average scores of liking.

Fig. 4 shows that for the second cluster ($C_3 = 2$, $n = 30$), the preferences can be described by a saddle point, with the highest preferences going in two different sensory directions, thus showing the need for using a model which can handle non-linear relations. A closer look at the raw data for this particular cluster ($C_3 = 2$) confirms that in general, the preferences of these consumers indeed go in opposite directions. One of the directions is represented by product 6 (17% fat content) which can be described as a product having a fermented sour flavour, a bitter taste and a sticky texture. The other direction can be represented by product 16 (10% fat content), which has a sweet taste and a grainy, rubbery and hard texture. The consumers in the cluster ($C_3 = 2$) seem to have a more complex preference pattern, perhaps due to more experiences with numerous types of cheese. On average, the liking scores for the first product set ranged from 3.7 to 7.1 (3.4), and the scores for the second product set ranged from 4.7 to 7.6 (2.9). Note that for this cluster, the difference in the average scores between the two product sets is also quite similar.

Fig. 5 shows a nearly linear preference for the third cluster ($C_3 = 3$, $n = 38$) going towards a fatty, soft, pale cheese with cream odour, cream flavour, acidic odour and acidic flavour, without reaching its preference maxima. This cluster ($C_3 = 3$) seems to consist of consumers who prefer cheeses with attributes similar to those often found in full-fat cheeses. Looking closer at the average scoring, one notices that the range in the average score is as large

Table 3

ANOVA table for 3 segments (C_3) and two components model (the mean absolute residual value is 1.356). n is the number of consumers within the segment, n_1 is the number of consumers within the segment who tested product set 1 and n_2 is the number of consumers within the segment who tested product set 2.

Segment	Number of individuals from each consumer group	Regression	DF	SS (Type I)	R^2	F	P
$C_3 = 1$ ($n = 47$)	$n_1 = 27$	Linear	2	85.41	0.1066	17.88	<0.0001
		Quadratic	2	49.87	0.0623	10.44	<0.0001
	$n_2 = 20$	Cross-product	1	6.49	0.0081	2.72	0.1004
		Total model	5	141.77	0.1770	11.87	<0.0001
$C_3 = 2$ ($n = 30$)	$n_1 = 11$	Linear	2	32.55	0.0432	4.93	0.0082
		Quadratic	2	109.58	0.1456	16.61	<0.0001
	$n_2 = 19$	Cross-product	1	36.73	0.0488	11.14	0.0010
		Total model	5	178.85	0.2376	10.85	<0.0001
$C_3 = 3$ ($n = 38$)	$n_1 = 21$	Linear	2	503.16	0.3916	73.13	<0.0001
		Quadratic	2	4.61	0.0036	0.67	0.5128
	$n_2 = 17$	Cross-product	1	13.50	0.0105	3.92	0.0488
		Total model	5	521.27	0.4057	30.30	<0.0001

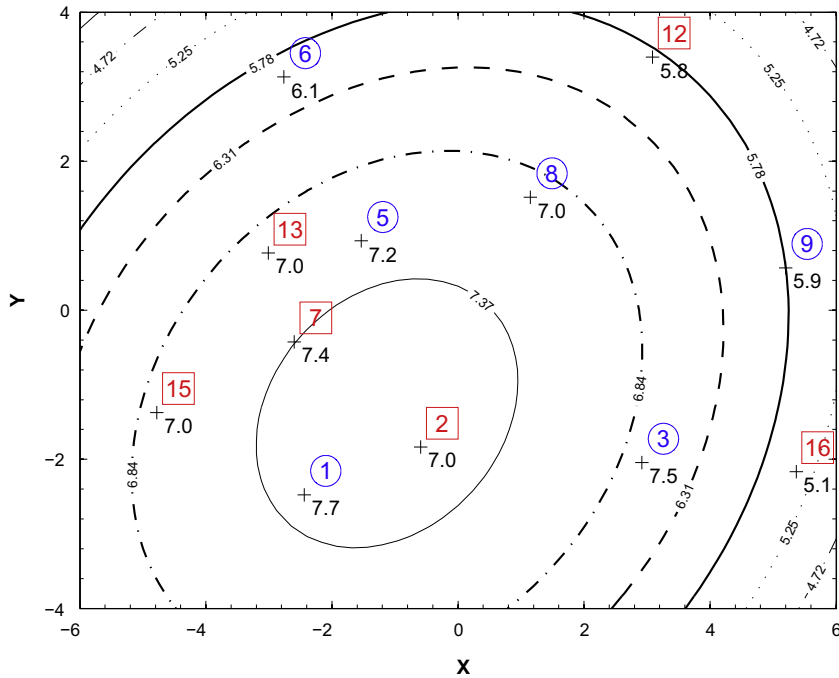


Fig. 3. Contour plot for the first segment from the two component three segment situation ($C_3 = 1$, size $n = 47$). Cheese presented to consumer group 1 is marked with a square and cheese presented to consumer group 2 is marked with a circle. The average scores from the 47 consumers are shown.

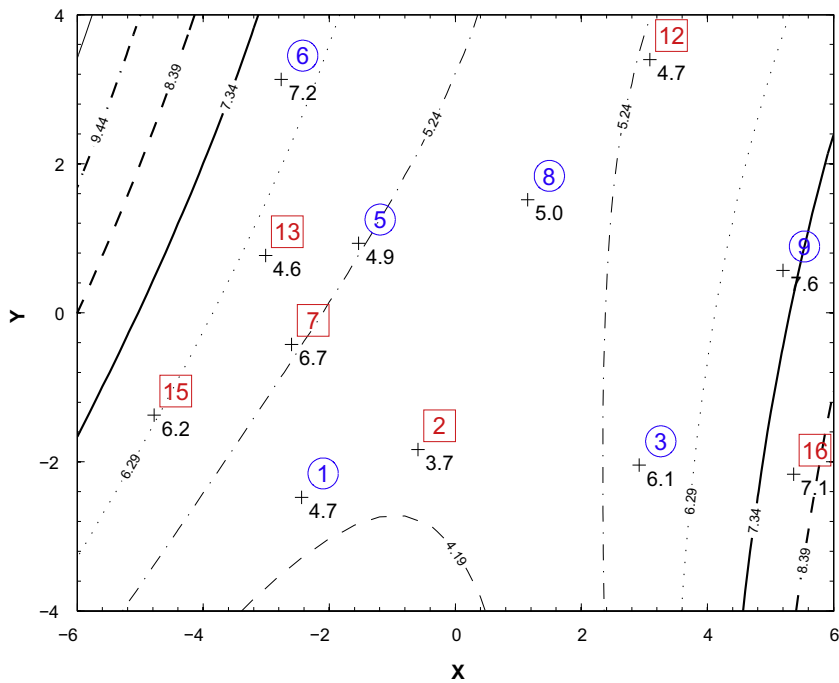


Fig. 4. Contour plot for the second segment from the two component three segment situation ($C_3 = 2$, size $n = 30$). Cheese presented to consumer group 1 is marked with a square and cheese presented to consumer group 2 is marked with a circle. The average scores from the 30 consumers are shown.

as 4.9 for the first product set (average score range from 2.4 to 7.3), and 4.3 for the other product set (average score range from 2.1 to 6.4). Again, the difference in the average liking scoring between the two product sets is quite small. A result like this could have occurred if the cluster consisted of individuals who used the extremes of the hedonic scale, but this was not the case here. The third cluster therefore seems to consist of consumers who are very particular in their cheese preference.

In the following, we will also consider briefly the solutions with 2 and 4 segments. The main reason for this is to see how dependent the conclusions above are on the choice of segments.

5.3.3. Results for 2PC's 2 segments

The analyses of variance for the two cluster solution gave R^2 's equal to 0.33 and 0.03. The latter is a very small value, which indicates that this is not a good cluster structure. As an example of how

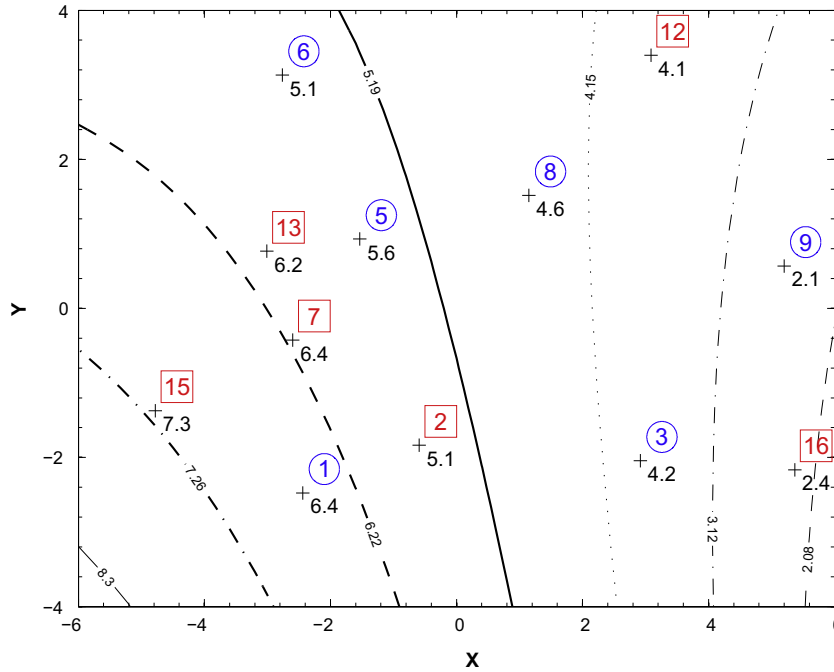


Fig. 5. Contour plot for the third segment from the two component three segment situation ($C_3 = 3$, size $n = 38$). Cheese presented to consumer group 1 is marked with a square and cheese presented to consumer group 2 is marked with a circle. The average scores from the 38 consumers are shown.

the membership values look, they are presented in Fig. 6 for the two cluster solution. As can be seen, many values are close to 0 and 1 which is a result of the small m value ($m = 1.1$), which is known to give a rather crisp clustering. The u -values closer to 0.5 represent those consumers with a weak membership to the two clusters. How to use the membership values will not be pursued further (see Bezdec (1981) for more information).

Contour plots of the two cluster models showed that one cluster was very linear, while the other cluster had a clear saddle point preference structure. Comparing the results from the two cluster

and three cluster solution, it seems that the most linear cluster in the two cluster situation consists mainly of individuals from the linear cluster in the three cluster situation (Fig. 5), (72% $C_3 = 3$, 19% $C_3 = 1$ and 9% $C_3 = 2$). The other cluster, which has a clear saddle point preference structure in the two cluster situation, is largely a merge of clusters one and two in the three cluster situation (Figs. 3 and 4) (56% $C_3 = 1$, 38% $C_3 = 2$ and 6% $C_3 = 3$). In other words, it seems that going from two to three clusters splits the cluster with a very small R^2 into two clusters with a much clearer structure.

5.3.4. Results for 2PC's 4 segments

In this case, the R^2 for the four models are 0.19, 0.30, 0.51 and 0.37, indicating a reasonable fit within each cluster. Contour plots of the four cluster models showed that one cluster was very similar to the cluster in Fig. 3 ($C_4 = 1$ consisted of 79% $C_3 = 1$), while other clusters were very similar to the general structure in Fig. 4 ($C_4 = 2$ consisted of 83% $C_3 = 2$). The last two clusters were quite linear, one with a preference going from the right to the left ($C_4 = 3$ consisted of 79% $C_3 = 3$) and one going from the top to the bottom of the plot ($C_4 = 4$ consisted of 21% $C_3 = 1$, 17% $C_3 = 2$ and 21% $C_3 = 3$). As seen, the additional cluster (going from three to four clusters) is made of individuals from all the clusters in the three segment solution. This means that the preference pattern of the linear cluster in the three cluster solution is sort of a compromise between the two linear clusters in the four cluster solution. It is interesting to note that the structure with a cluster having preferences at opposite sides of the plot is maintained when going from three to four clusters.

6. Conclusion

This study tested a new approach to product set selection and segmentation in preference mapping. The selection method allowed for different products to be tested by different consumers. It was shown that fuzzy clustering with the use of residual distance can be a useful tool for the segmentation of consumers in preference mapping. In particular, this method was tested for ideal point

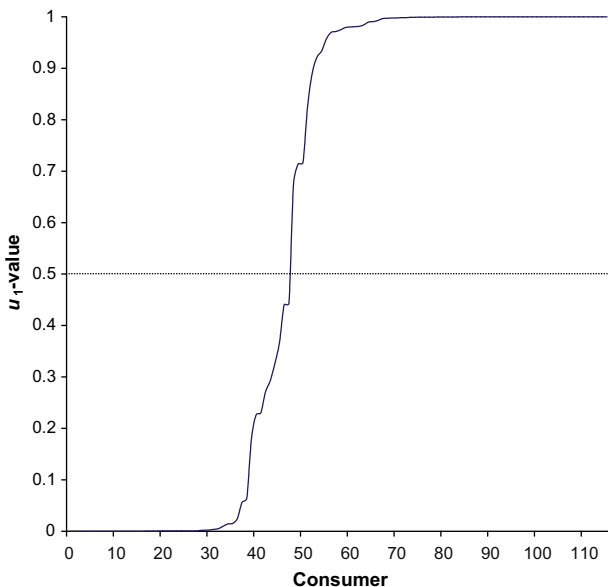


Fig. 6. Plot of u_1 -values for the two component two cluster solution ($m = 1.1$). The plot for u_2 is opposite since the sum of u_1 and u_2 is 1. The consumers here are sorted according to u value.

models. The method also proved useful in keeping the number of served products low (reducing the cost of the study and minimizing the risk of fatigue, adaptation and satiety), while still being able to model the preferences of different consumer segments. The case study focused on two principal components. The method can, however, also be used in situations with more principal components in the model. Since residuals are used as criterion in the fuzzy clustering, the procedure easily handles the different sets of products served to the different consumer groups. Three different preference patterns for low-fat cheese were characterized in the case study. The method proved stable with respect to the cluster solutions found, and no convergence problems were detected.

Acknowledgements

This work was part of the project “Low energy products and consumer preferences”, and was financed by the Research Council of Norway (NFR) through grant 167928/110. The authors wish to thank TINE BA, Norway, for allowing the use of data from the low-fat dairy project. Jakob Lund Laugesen is thanked for MATLAB programming of the contour plots. In addition, the authors want to thank the referees for their constructive and valuable comments.

References

- Berget, I., Mevik, B. H., & Næs, T. (2008). New modifications and applications of fuzzy C-means methodology. *Computational Statistics and Data Analysis*, 52, 2403–2418.
- Bezdec, J. C. (1981). *Pattern recognition with fuzzy objective function algorithms*. New York: Plenum Press.
- Earthy, P. J., MacFie, H. J. H., & Hedderley, D. (1997). Effect of question order on sensory perception and preference in central location trials. *Journal of Sensory Studies*, 12(3), 215–237.
- Gambaro, A., Ares, G., Gimenez, A., & Pahor, S. (2007). Preference mapping of color of Uruguayan honeys. *Journal of Sensory Studies*, 22(5), 507–519.
- Green, P. E., & Srinivasan, V. (1978). Conjoint analysis in consumer research – Issues and outlook. *Journal of Consumer Research*, 5(2), 103–123.
- Gustafsson, A., Herrmann, A., & Huber, F. (2003). *Conjoint measurement. Methods and applications*. Berlin: Springer.
- Helgesen, H., Solheim, R., & Næs, T. (1997). Consumer preference mapping of dry fermented lamb sausages. *Food Quality and Preference*, 8(2), 97–109.
- ISO (1988). International Standard 8589. Sensory analysis – General guidance for the design of test rooms. [Ref. No. ISO 8589:1988 (E)]. Genève: International Organisation for Standardisation.
- ISO (1993). International Standard 8586-1. Sensory analysis – Methodology – General guidance for the selection, training and monitoring of assessors. [Ref. No. ISO 8586-1:1993 (E)]. Genève: International Organisation for Standardisation.
- Lawless, H., & Heymann, H. (1999). *Sensory evaluation of food. Principles and practices*. New York: Kluwer Academic/Plenum Publishers.
- MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies*, 4(2), 129–148.
- Mardia, K. V., Kent, J. T., & Bibby, J. M. (1980). *Multivariate analysis*. London: Academic Press.
- Martens, H., & Martens, M. (2001). *Multivariate analysis of quality. An introduction*. Chichester: John Wiley and Sons.
- Martens, H., & Næs, T. (1989). *Multivariate calibration*. Chichester: John Wiley and Sons.
- McEwen, J. A. (1996). Preference mapping for product optimization. In T. Næs & E. Risvik (Eds.), *Multivariate analysis of data in sensory science* (pp. 71–102). Amsterdam: Elsevier Science.
- Næs, T., & Isaksson, T. (1991). Splitting of calibration data by cluster-analysis. *Journal of Chemometrics*, 5(1), 49–65.
- Næs, T., Kubberød, E., & Sivertsen, H. (2001). Identifying and interpreting market segments using conjoint analysis. *Food Quality and Preference*, 12(2), 133–143.
- Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preference. *Food Technology, Symposium*, 11(9), 9–14.
- Riviere, P., Monrozier, R., Rogeaux, M., Pages, J., & Saporta, G. (2006). Adaptive preference target: Contribution of Kano's model of satisfaction for an optimized preference analysis using a sequential consumer test. *Food Quality and Preference*, 17(7–8), 572–581.
- Rousseeuw, P. J. (1995). Fuzzy clustering at the intersection – Discussion. *Technometrics*, 37(3), 283–286.
- Schlich, P., & McEwan, J. A. (1992). Preference mapping – A statistical tool for the food-industry. *Sciences Des Aliments*, 12(3), 339–355.
- Wedel, M., & Kamakura, W. A. (1998). *Market segmentation: Conceptual and methodological foundations*. Boston: Kluwer Academic Publishers.
- Wedel, M., & Steenkamp, J.-B. E. M. (1989). A fuzzy clusterwise regression approach to benefit segmentation. *International Journal of Research in Marketing*, 6(4), 241–258.
- Wedel, M., & Steenkamp, J.-B. E. M. (1991). A clusterwise regression method for simultaneous fuzzy market structuring and benefit segmentation. *Journal of Marketing Research*, 28(4), 385–396.
- Zahid, N., Limouri, N., & Essaid, A. (1999). A new cluster-validity for fuzzy clustering. *Pattern Recognition*, 32(7), 1089–1097.
- Zemroch, P. J. (1986). Cluster-analysis as an experimental-design generator, with application to gasoline blending experiments. *Technometrics*, 28(1), 39–49.

Paper III



Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information

Susanne Bølling Johansen^{a,b,*}, Tormod Næs^{a,c}, Jorun Øyaas^d, Margrethe Hersleth^{a,b}

^a Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway

^b Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, P.O. Box 5003, NO-1432 Ås, Norway

^c Department of Mathematics, University of Oslo, P.O. Box 1053 Blindern, NO-0316 Oslo, Norway

^d TINE BA, P.O. Box 25, NO-0051 Oslo, Norway

ARTICLE INFO

Article history:

Received 25 April 2008

Received in revised form 23 June 2009

Accepted 10 July 2009

Available online 15 July 2009

Keywords:

Conjoint analysis

Sensory

Information

Consumer

Acceptance

Yoghurt

Health

ABSTRACT

The main objective of this paper was to study acceptance of yoghurt with different levels of two specific sensory attributes, sweetness and richness, when corresponding information about sugar and fat content was given simultaneously with tasting. A conjoint design was applied to examine the effects of intrinsic attributes (sensory) and extrinsic attributes (health information) on acceptability and purchase probability for calorie-reduced vanilla yoghurt. Based on sensory profiling of 12 yoghurts produced according to an experimental design, four yoghurts varying in sweetness and richness were selected. In the conjoint study this sensory variation was combined with information concerning fat content and sugar content. 153 health conscious consumers participated in a blind testing and a conjoint study. Analyses of variance showed that sweetness and information about sugar content had significant effects on liking and purchase probability. The study showed that conjoint methodology was an appropriate tool to reveal effects of extrinsic and intrinsic product attributes.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

In recent years there has been an increase in the number of food products available on the market with extrinsic information given about various product characteristics such as nutritional value (Ginnon, Lohéac, Martin, Combris, & Issanchou, 2009; Visschers & Siegrist, 2009), functional properties (Ares, Gimenez, & Gambaro, 2009; Urala & Lahteenmaki, 2006), origin of raw materials (Schnettler, Vidal, Silva, Vallejos, & Sepulveda, 2009; Stefani, Romano, & Cavicchi, 2006) and production process (Laccarino, Di Monaco, Mincione, Cavella, & Masi, 2006; Nielsen et al., 2009). Studies have shown that information about health properties may affect consumer acceptance and purchase intent (Helgesen, Solheim, & Næs, 1998; Kähkönen, Hakanpaa, & Tuorila, 1999; Shepherd, Sparks, Bellier, & Raats, 1991/2; Westcombe & Wardle, 1997). However, these effects may be dependent on the type of food product tested (Wansink, 2003).

1.1. Combinations of intrinsic and extrinsic attributes for dairy products

For the dairy product category, studies have shown a positive effect of information about fat reduction on acceptance for spreads (Aaron, Mela, & Evans, 1994; Kähkönen, Tuorila, & Rita, 1996), cheese (Light, Heymann, & Holt, 1992) and to some degree for ice cream (Light et al., 1992). On the other hand, similar effects have not been observed for yoghurt (Kähkönen, Tuorila, & Lawless, 1997). Several of these studies have combined different types of product information with tasting of the same product, i.e. variations in the sensory dimensions were not introduced during the experiments. Regarding calorie-reduced products it is important to note that although health information is likely to affect choice on a first time purchase, the sensory dimensions and the product experience will probably be the prime factors for re-purchase (Grünert, 2003). This mechanism is strongly related to the theory of expectation (Anderson, 1973; Deliza & MacFie, 1996). In the case of calorie reduce products, both sensory and hedonic expectations will play an important role for product acceptance and consumer satisfaction (Cardello, 1995; Cardello & Sawyer, 1992).

* Corresponding author. Address: Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway Ås, Norway. Tel.: +47 64970482; fax: +47 64970333.

E-mail address: susanne.johansen@nofima.no (S.B. Johansen).

1.2. Conjoint analysis for combining tasting with extrinsic product attributes

Conjoint analysis is a well known approach within marketing for exploring the effects of and interactions between several product attributes on consumer acceptance (Green & Rao, 1971; Johnson, 1974). In conjoint studies consumers are presented with a variety of products or images, each differing from the others on a set of chosen attributes (Green & Rao, 1971; Green & Srinivasan, 1978; Green & Wind, 1975). The respondents are either asked to make a choice between several products, to rank products or to rate products according to degree of acceptance or probability of purchase (Enneking, Neumann, & Henneberg, 2007; Jaeger, 2000). Conjoint analysis reveals the relative importance of each attribute, thus providing concrete information about which product attributes and their interactions that are most important for acceptance and food choice. Hence, by including tasting of products i.e. sensory variation as a factor in conjoint, this may be a suitable method for estimating the effects of both intrinsic (sensory properties) and extrinsic (health related product information) product attributes and their interactions, with regard to acceptance and purchase probability (Miyazaki, Grewal, & Goodstein, 2005; van Trijp & Schifferstein, 1995).

There already exist some studies in the literature where product tasting has been incorporated in a conjoint framework. Important examples involving price and information of fat content are Solheim and Lawless (1996), Helgesen et al. (1998) and Haddad et al. (2007), who studied cheese, sausages and yoghurt, respectively. All these studies indicated that sensory quality has a primary effect on purchase intent and that extrinsic attributes may have a secondary effect. A recent choice-based conjoint study on soft drinks (Enneking et al., 2007) showed that sensory properties had a large impact on product choice and that only if the consumers had no product preference, the information positively impacted choice. In all these examples sensory variation was incorporated in the design since concrete products were used, but sensory properties were not specifically highlighted. Therefore, it is very difficult to identify what are the actual sensory drivers of liking, which is often of major concern in product development. For this purpose, sensory analysis is needed both for ensuring that samples span the relevant sensory space and as part of the data analysis itself.

1.3. Current challenges and objectives of the study

The dairy industry in Norway has during the last decade been facing challenges as the Norwegian media have been focusing on the amount of sugar in flavoured yoghurt. A consequence has been an increased market demand for yoghurt with both reduced content of fat and sugar and, at the same time, many consumers expect the sensory quality to be similar to the original product. The importance of consistency and sweetness for acceptance of flavoured yoghurt has been confirmed in several studies (Barnes, Harper, Bodyfelt, & McDaniel, 1991; Duboc & Mollet, 2001; Mojet & Köster, 2005; Tuorila, Somnardahl, Hyvönen, Leporanta, & Merimaa, 1993). Hence, a crucial aspect for the industry is to be able to produce a low-fat and low sugar product that is acceptable for consumers with respect to both sweetness and consistency properties. In order to achieve this, a better understanding of the relative importance of the sensory attributes and health related information and how they possibly interact is needed. At present, no clear results exist in the literature regarding this for low-calorie yoghurt.

The main objective of this paper is to study consumer acceptance of yoghurt with focus on consistency and sweetness and corresponding information about sugar and fat content. As a measure of consistency we have decided to concentrate on an attribute that will be described as richness (or rich consistency), which is typi-

cally associated with yoghurt. A new approach to experimental design in conjoint methodology is introduced, which focuses explicitly on sensory attributes and their relevant variability. The method is constructed in such a way that it is easy to combine the selected samples with extrinsic attributes in the full experimental setup for the study, using regular factorial design methodology. Analysis of the conjoint data will be done using standard mixed model ANOVA methodology with all the four factors involved. Estimates of the effects sizes as well as tests of significance will be provided. It is our hypothesis that this approach may contribute to a more explicit focus on what are the important reasons for consumers' acceptance of the products.

2. Material and methods

We refer to Fig. 1 for an illustration of the various steps in the approach taken.

2.1. General structure of the sample selection strategy

When combining intrinsic and extrinsic attributes in conjoint analysis, the question is how the samples should be selected and combined with the extrinsic attributes. In this study we are interested in sensory dimensions and how to include these as design variables. The most important aspect is that the samples should span the relevant sensory dimensions within realistic limits and enough to make estimation reliable. Another criterion is that the selected samples should be possible to combine with the extrinsic variables in such a way that interactions can be revealed and at the

General structure of the sample selection strategy:

2⁴⁻¹ fractional factorial design for conjoint testing

Sample production:

Production of 12 calorie reduced yoghurts

Sensory profiling:

Sensory descriptive analysis of the 12 samples

Sample selection for consumer study:

Selection of 4 samples and 1 "dummy sample"

Focus groups:

Evaluation of information about reduction of fat and sugar content

Experimental consumer study:

Blind testing

Tasting of 5 samples without information

One week later

Conjoint testing

Written and verbal instructions

Tasting of 8 samples with information about fat and sugar content using conjoint methodology

Completion of the health and taste attitude scale (Roininen et al. (1999)) as well as socio- and demographics questions

Fig. 1. Experimental flow-chart.

same in such a way that the experiment is not made unnecessarily large for the purpose.

The classical way of selecting samples in conjoint analysis is to consider them as individual levels of one single experimental factor, and to combine these samples with the extrinsic attributes in a full factorial design. This approach is not fully satisfactory. The main reason for this is that the samples may possibly not span the important sensory attributes in a satisfactory way, since these variables are not taken into account in the selection. Another challenge is that sometimes a full factorial experimental design may become too large and the use of a fractional factorial design in situations including several levels is relatively complicated. For instance, the confounding pattern, which is of particular interest in studies of this type with a strong focus on interactions between factors, may be complex and difficult to obtain. The strategy in this paper is therefore based on ideas of fractional factorial designs with two levels for each factor.

The following strategy was used in this study:

- The first step was to generate a relatively large number of samples that together span the realistic and relevant variability of the sensory attributes. This was done by the use of an experimental design where a number of the important input factors (ingredients) were varied systematically.
- The next step was to analysis all samples by the use of sensory profiling.
- The sensory data were submitted to PCA and the scores plot and loadings plot created.
- The design samples were selected from the PCA scores plot such that they satisfy the criteria discussed above. This was obtained by selecting them according to a geometric structure similar to a rectangle in the two-dimensional principal component space. The corners of the rectangle are selected in such a way that the rectangle represents the whole space of variability (all “quadrants” are represented) and that the two rectangular directions correspond as well as possible to the two most important sensory dimensions in this case, richness and sweetness. It is important to note, that these directions do not only relate to sweetness and richness, but to several sensory attributes which are more or less correlated. The two dimensions in the rectangle can be thought of as new latent orthogonal variables, here called “meta-attribute”, closely related to sweetness and richness, but with the additional interpretation that can be read out of the loadings plot.
- The two meta-attributes represent the two sensory dimensions, variables with two levels each according to the corners of the rectangle, to be combined with the two related information variables. This was done using basic fractional factorial design strategies with two levels of each factor. The study will thus be based on a design with essentially four two level factors, two intrinsic factors and two extrinsic factors. Since eight combinations for

each consumer was considered the maximum number here, the experimental design chosen was a 2^{4-1} fractional factorial design of resolution IV. This means that none of the two-factor interactions are confounded with the main effects, but two-factor interactions are confounded with each other. The design is given in Table 1.

This approach guarantees that the selected samples span the whole space of relevant sensory variability well: In this particular case the two most important sensory attributes in the study are close to uncorrelated, which is an advantage for the ability to assess the individual contributions of the two sensory dimensions. Secondly, the combination with additional attributes is simple and relies only on two level designs which are easy to use since they are transparent with respect to the confounding structure but also allows for simple estimation of both main effects and two-factor interactions.

2.2. Production of yoghurt samples

The chosen product in this study was vanilla yoghurt. Studies at Nofima Mat have shown a relatively strong correlation between consistency properties as richness, creaminess and fattiness in descriptive analyses of yoghurt (not published). We decided to focus on richness as the most appropriate sensory attribute to represent this variation (see Section 2.3). The most important aspect at this stage was to ensure that the variability in the sensory attributes of interest was relevant and realistic for the study of the two extrinsic attributes in focus. This was mainly done by varying the content of sugar and fat. However, it should be noted that sugar may not only influence the sweetness in yoghurt, but also the oral perception of fat (Drewnowski, 1993). Addition of sugar to low-fat dairy products, like skim milk or yoghurt, have been shown to increase ratings of fattiness and creaminess (Drewnowski & Greenwood, 1983; Tuorila et al., 1993). Based on this information and discussions with technologists at the dairy manufacturer TINE BA, a full factorial design of 12 different samples of vanilla yoghurt were produced varying in their content of fat, sugar, and cream aroma (720159H Cream Flavour, Givaudan, Switzerland) but not in vanilla flavouring (80811013 Vanilla, Frutarom Switzerland Ltd., Switzerland). The chosen levels of sugar were 9%, 11% and 13%, the levels of fat were 0.1% and 1.5%, and the levels of cream aroma were 0% and 0.05%. All these levels are within realistic limits when it concerns this type of calorie-reduced yoghurt. Yoghurt bases produced by TINE BA were used for the sample production. It should be noted that the low-fat yoghurt base (0.1% fat) contained gelatine while the high fat yoghurt base (1.5% fat) did not.

After sensory profiling (Section 2.3) a second production of yoghurt was performed to reproduce the samples selected for the consumer testing (Section 2.4) i.e. four samples along with two extra samples used for preparation of a blended dummy sample (Section 2.5.2).

2.3. Descriptive sensory analysis

A trained panel of ten assessors at Nofima Mat performed a sensory descriptive analysis according to “Generic Descriptive Analysis” as described by Lawless and Heymann (1999). The assessors were tested, selected and trained according to ISO standards (ISO, 1993), and the sensory laboratory used followed the ISO standards (ISO, 1988). The assessors agreed upon 18 attributes describing the yoghurt samples. All attributes were evaluated on an unstructured line scale with labelled endpoints going from no intensity (value 1.0) at the left side to high intensity (value 9.0) at the right side. In a pre-test session, the assessors were calibrated on samples that were considered most different on the selected attributes typical

Table 1

2^{4-1} -design used for the conjoint analysis. Four samples were served two times with different information. – indicates the lowest level of the factor. + indicates the highest level of the factor.

Sweetness	Richness	Information about sugar content	Information about fat content	Sample No. in PCA
–	–	–	+	7
+	–	–	–	12
–	+	–	–	1
+	+	–	+	6
–	–	+	–	7
+	–	+	+	12
–	+	+	+	1
+	+	+	–	6

for the yoghurts to be tested. Samples were served in plastic cups labelled with three-digit numbers. The serving temperature of the samples was 12 °C as recommended for sensory evaluation of fermented dairy products (IDF-Standard, 1997). Tap water and crackers were available. Two replicates were performed for each yoghurt sample. All samples and replicates were served in randomised order. The average response over replicates and assessors for the significant attributes were used in the multivariate data analyses. Similar procedure was used for samples from the second production of yoghurt.

2.4. Selection of samples for the consumer study

A correlation loadings plot from the principal component analysis (PCA) of the significant sensory attributes for the 12 yoghurt samples is presented in Fig. 2. The samples were included as dummy variables (down-weighted in the data matrix) in the PCA to improve the visual interpretation as suggested in Martens and Martens (2001). The two first components accounted for 88% of the variation (58% and 30%) while the third component accounted for 8% of the variation in the sensory data. The full cross validation (results not shown) confirmed that interpretation of the first three components is valid. Since as much as 88% was explained in the two first components and since the most important attributes contributed strongly to these two dimensions, two components were used for the selection of samples.

According to the general principles above, one sample was selected from each quadrant in the PCA plot in order to fit the structure of a 2² factorial design, i.e. a rectangle (marked with large font size in Fig. 2). The selected samples for the consumer study were sample 1 (0.1% fat and 9% sugar), sample 6 (0.1% fat, 13% sugar and added cream aroma), sample 7 (1.5% fat and 9% sugar) and sample 12 (1.5% fat, 13% sugar and added cream aroma).

In Fig. 2, both sweetness and richness are related to a number of attributes given by the original experimental design which defines

the “population” of interest here. This implies that no causal effect on hedonic liking from the consumer study can be attributed to one particular sensory attribute, only to a sensory dimension which is related to several sensory attributes, which is a situation very typical for sensory data.

In addition to the four selected samples (sample 1, 6, 7 and 12) a “centre sample” was selected as a dummy sample (described in 2.5.2). This sample was produced by blending equal amounts of sample 4 (0.1% fat, 9% sugar and added cream aroma) and sample 9 (1.5% fat and 13% sugar) (marked with medium font size in Fig. 2).

The PCA of the sensory descriptive data from the second production of yoghurt showed similar patterns to the PCA from the first yoghurt production, indicating a stable production.

2.5. Consumer study

The consumer study consisted of two parts: A pre-study with focus groups and the main experiment using conjoint methodology which included tasting of yoghurt.

2.5.1. Focus groups

Studies have shown that consumers have limited knowledge of actual nutritional content and the health implications of this (Ares, Gimenez, & Gambaro, 2008; Oakes & Slotterback, 2001). Two focus groups were conducted to provide insight in Norwegian consumers' awareness regarding nutritional content in flavoured yoghurt, and to select the best way of giving nutritional information during the conjoint. Results indicated that Norwegian consumers generally have little knowledge and consciousness about the actual fat and sugar level in yoghurts on the market. Another result from the focus groups was that the consumers' found pie charts useful for illustration of levels of fat and sugar content in yoghurt (shown in Fig. 3). The decision was therefore made that this seemed to be the most relevant way of communicating fat and sugar content during this experiment.

2.5.2. Experimental consumer study

The consumers were recruited by a market analysis agency according to the following criteria: Consumers of yoghurt (\geq twice a week), 24–40 years of age, residing in the eastern part of Norway and with a normal or high interest in health. The latter criterion was based on degree of agreement with the following two statements: “I am concerned about health and nutrition when I buy and consume food from the grocery store” and “When it comes to food purchase in the grocery store, I usually choose the healthier alternative, i.e. I choose the product with fewer calories rather than the regular product”. Responses to these two statements were measured on a five point scale going from completely agree (5) to completely disagree (1). To participate in the study the consumer had to completely agree (5) or highly agree (4) with both statements. In total 153 consumers (63% women and 37% men) participated throughout the study.

The consumer test was organised in two sessions with a one week break in between. All samples were tested by the consumers at a temperature of 7 °C. The first week, a blind testing was conducted, i.e. a hedonic evaluation of five yoghurt samples without any information. This test was done to be able to compare conjoint results (informed testing) with blind testing (no information). The session started with a warm-up sample (dummy sample) to eliminate the first position bias, as suggested by Kim and Setser (1980). The following four samples were served one by one in an order using a balanced design (MacFie, Bratchell, Greenhoff, & Vallis, 1989). Consumers rated their degree of liking on a modified version of the nine point hedonic scale by Peryam and Pilgrim (1957). The modified scale was anchored with “Dislike Extremely”

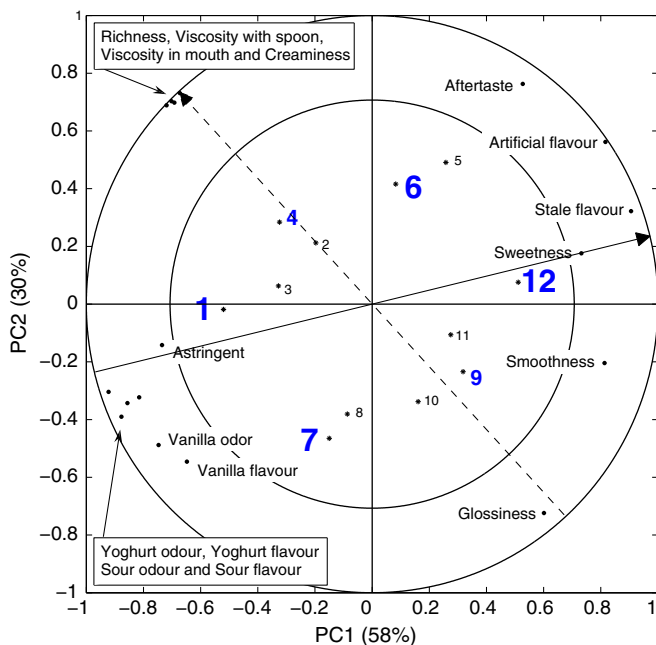


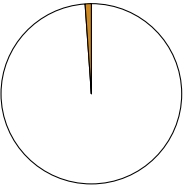
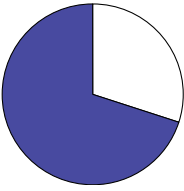
Fig. 2. Correlation loadings plot from PCA of significant sensory attributes from 12 yoghurt samples. The four samples selected for the conjoint testing have the largest font size (1, 6, 7 and 12), where as the blended samples used as a “dummy sample” in the blind testing have medium font size (4 and 9). * = sample and ● = sensory descriptor. The solid arrow represents the direction of the meta-attribute sweetness, while the dashed arrow represents the direction of the meta-attribute richness.

Consumer number: _____

Code: **034**

READ THE INFORMATION:

Fat Content: **Sugar Content:**

TASTE THE SAMPLE:

Indicate on the scale how much you like the yoghurt:

1 = "don't like at all" 5 = "neither like/nor dislike" 9 = "like very much"

How much do you like the yoghurt?

Don't like at all 1 2 3 4 5 6 7 8 9 Like very much

□ □ □ □ □ □ □ □ □

Indicate on the scale how likely it is that you would buy the yoghurt if it is sold at an acceptable price:

1 = "wouldn't buy it at all" 9 = "would surely buy it"

How likely is it that you would buy this yoghurt if it is sold at an acceptable price?

Wouldn't buy it at all 1 2 3 4 5 6 7 8 9 Would surely buy it

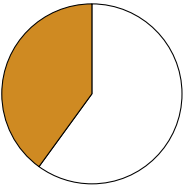
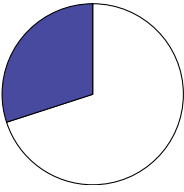
□ □ □ □ □ □ □ □ □

Consumer number: _____

Code: **161**

READ THE INFORMATION:

Fat Content: **Sugar Content:**

TASTE THE SAMPLE:

Indicate on the scale how much you like the yoghurt:

1 = "don't like at all" 5 = "neither like/nor dislike" 9 = "like very much"

How much do you like the yoghurt?

Don't like at all 1 2 3 4 5 6 7 8 9 Like very much

□ □ □ □ □ □ □ □ □

Indicate on the scale how likely it is that you would buy the yoghurt if it is sold at an acceptable price:

1 = "wouldn't buy it at all" 9 = "would surely buy it"

How likely is it that you would buy this yoghurt if it is sold at an acceptable price?

Wouldn't buy it at all 1 2 3 4 5 6 7 8 9 Would surely buy it

□ □ □ □ □ □ □ □ □

Fig. 3. Examples of forms used in the conjoint study. The information about the fat and sugar content were given simultaneously in the shape of pie charts. Code 034: low-fat, high sugar content. Code 161: high fat, low sugar content. This information was relative to the 4% fat content and 16% sugar content in average full fat flavoured yoghurt on the Norwegian market.

and "Like Extremely" and with a neutral centre point of "Neither Like nor Dislike".

The following week the conjoint test was conducted. The consumers were informed about fat content and sugar content according to a form shown in Fig. 3. They rated degree of liking and purchase probability provided an acceptable price, on a nine point scale for the eight combinations of attributes. Verbal and written instructions were given prior to testing: The consumers were told that they were about to taste eight different calorie-reduced yoghurts varying both in fat and sugar content and that possible minor changes in the production process might have been introduced to achieve a good product. The latter statement was included as both true and false information were given simultaneously during the conjoint (see Table 1). As initial instructions the consumers were told that a full filled pie corresponded to 4% fat content and 16% sugar content in the "standard Norwegian TINE yoghurt" (which has been on the market for the last 20 years) and they were explained how to interpret the information indicating the fat and sugar content in each sample (see Fig. 3). The last part of the session included questions related to socio-demographics, and health and taste attitudes (Roininen, Lahteenmaki, & Tuorila, 1999). When they finished, each of the consumers received a gift card and any questions concerning the study were answered.

2.6. Statistical analysis

2.6.1. Analysis of descriptive sensory data

Analysis of variance (ANOVA) using a two-way model with interactions and with the assessor and interaction effects considered random, was performed on the descriptive sensory data (for both yoghurt sample productions) in order to identify the sensory attributes that discriminated between samples. The model used can be written as.

$$Y_{ijk} = \mu + A_i + P_j + AP_{ij} + \varepsilon_{ijk}$$

where Y_{ijk} is the (ijk)th observation, μ is the general mean, A_i and P_j , are the main effects of assessor and product, AP_{ij} is the interaction effect and ε_{ijk} is the random error.

To study the variation between the average sensory descriptive data and for the purpose of selecting samples for the consumer test, a PCA of the panel averages (significant attributes, $p < 0.05$) was performed (mean centred data, no standardisation) (Mardia, Kent, & Bibby, 1980). Full cross validation (Martens & Næs, 1989) was used for validation of the components. The multivariate analysis was performed in The Unscrambler version 9.2 (Camo AS, Oslo, Norway).

2.6.2. Analysis of consumer data

2.6.2.1. Blind testing. The data obtained from the blind testing were analysed with the following model having main effects and two-factor interactions for the design variables, and a random effect for consumer and for its first order interactions with the design variables:

$$Y_{ijk} = \mu + S_i + R_j + SR_{ij} + C_k + SC_{ik} + RC_{jk} + \varepsilon_{ijk}$$

Here Y_{ijk} is the (ijk)th observation, μ is the general mean, S_i and R_j , are the main effects of the two meta-attributes sweetness and richness and SR_{ij} are their interaction effect. These are all fixed effects. C_k is the main effect of consumers, SC_{ik} and RC_{jk} are the interactions between consumers and design variables and ε_{ijk} is the random error. These are all random effects. The standard assumption of independent and homoscedastic random effects was used. The analysis was performed with SAS PROC MIXED version 9.1 (Statistical Analysis Systems, Cary, NC) using restricted maximum likelihood estimation. The analysis was performed with Satterthwaite's approximation for the number of denominator degrees of freedom.

2.6.2.2. Conjoint study. The data obtained in the conjoint experiment (representing liking and purchase probability) were analysed using the following model with main effects and two-factor interactions for the design variables plus random effect of consumer and its first order interaction with the design variables:

$$Y_{ijklm} = \mu + S_i + R_j + I_k + J_l + SR_{ij} + SI_{ik} + SJ_{il} + RI_{jk} + RJ_{jl} \\ + IJ_{kl} + C_m + SC_{im} + RC_{jm} + IC_{km} + JC_{lm} + \varepsilon_{ijklm}$$

Here Y_{ijklm} is the $(ijklm)$ th observation, μ is the general mean, S_i , R_j , I_k and J_l are the main effects of the two meta-attributes sweetness and richness, information about sugar content and information about fat content, respectively. SR_{ij} , SI_{ik} etc. are their interaction effects. All these are fixed effects. Note that in the conjoint design some of the interactions are confounded with each other, thus not all interactions are possible to incorporate. C_m is the main effect of consumers, the SC_{im} , RC_{jm} etc. are the interactions between design variables and consumers and ε_{ijklm} is the random error. These are all random effects. All random effects are assumed to be independent and homoscedastic. The analysis was performed with SAS PROC MIXED version 9.1 (Statistical Analysis Systems, Cary, NC) using restricted maximum likelihood estimation. The analysis was performed with Satterthwaite's approximation for the number of denominator degrees of freedom.

The consumer attitude data were related to acceptance data by the use of partial least squares (PLS) regression (consumer preferences as X-variables and various attitudes as Y-variables). Full cross validation (Martens & Næs, 1989) was used for validation of the components. The multivariate analysis was performed in The Unscrambler version 9.2 (Camo AS, Oslo, Norway). The PLS score plot was split in two according to high or low score along the first axis. This splitting in two was identified by a dummy variable and then used in an ANOVA model.

3. Results

3.1. Blind testing

The results from the ANOVA of results from blind testing are shown in Table 2. As can be seen, there are significant main effects of sweetness ($p = 0.00$) and richness ($p = 0.03$) and a significant interaction effect between these factors ($p = 0.00$) on liking. The average likings for the four samples in blind testing are shown in Fig. 4. The figure shows that yoghurt samples with highest intensity in sweetness got the highest scores by the consumers (samples 6 and 12). A probable explanation for the interaction effect is that an increase in richness had a (minor) negative influence on acceptance for the least sweet yoghurts (sample 1 and 7), but a positive influence on acceptance for the sweetest yoghurts (sample 6 and 12).

3.2. Conjoint testing

The results from the ANOVA with all the four experimental factors in the conjoint are shown in Table 3. For liking, the table shows significant main effects of the meta-attributes sweetness ($p = 0.00$)

Table 2

Results from ANOVA on the effects of the sensory attributes on liking in the blind testing.

Variable	Liking P^a
Sweetness	0.00
Richness	0.03
Sweetness \times richness	0.00

^a P -values for fixed main effects and interaction effects (0.00 means a P -value ≤ 0.001).

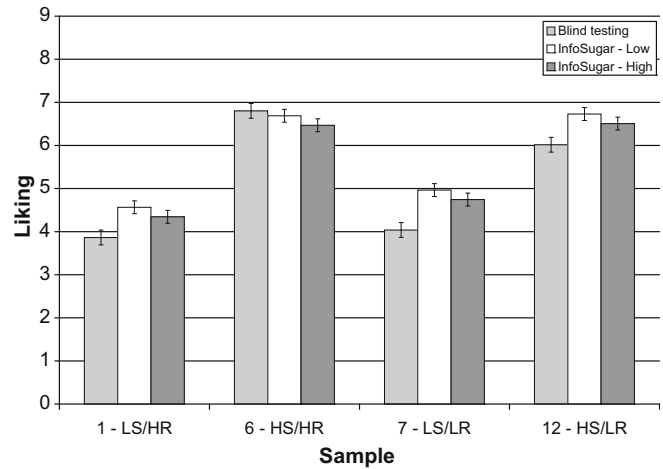


Fig. 4. Average liking of the samples tested blind, with low sugar content information and with high sugar content information. Results are averaged over information about the fat content (not significant). 1: low sweetness (LS) and high richness (HR), 6: high sweetness (HS) and high richness (HR), 7: low sweetness (LS) and low richness (LR), 12: high sweetness (HS) and low richness (LR). The standard errors (indicated on top of the bars) were computed as an approximation of the corresponding variance as the sum of the two variances of the LSMEANS contributions used to compute the height (the main effect and interaction contributions).

Table 3

Results from ANOVA on the effects of the factors on liking and purchase probability in the conjoint study.

Variable	Liking P^a	Purchase probability P^a
Sweetness	0.00	0.00
Richness	0.01	0.08
Information about sugar content	0.01	0.00
Information about fat content	0.79	0.62
Sweetness \times richness or infosugar \times infofat	0.03	0.24
Sweetness \times infosugar or richness \times infofat	0.16	0.36
Sweetness \times infofat or richness \times infosugar	0.82	0.64

^a P -values for fixed main effects and interaction effects (0.00 means a P -value ≤ 0.001).

and richness ($p = 0.01$), significant effect of information about sugar content ($p = 0.01$) and significant effect either of the interaction between sweetness and richness or the information about sugar and information about fat ($p = 0.03$). For purchase probability, the significant effects are the main effects of sweetness ($p = 0.00$) and information about sugar content ($p = 0.00$). The correlation between the responses for liking and purchase probability using the Pearson correlation coefficients were 0.89 ($N = 1224$ and $p = 0.00$). A general tendency in the raw data showed that liking on average was given relatively higher scores than purchase probability (results not shown).

The average effects of the four factors in the conjoint are shown in Fig. 5. The absolute values of the effects range from 0.01 to 1.94 for liking and 0.07–2.16 for purchase probability. As can be seen, only sweetness has a positive effect on liking and purchase probability, and this effect is relatively large compared to the others. An increase in richness as well as information about a high content of sugar had significant negative effects on liking. For purchase probability only information about high sugar content had a significant negative effect.

Fig. 4 shows the average liking of the samples tested without information (blind test) and with different information about the samples' sugar content (low and high). In the figure, the results are averaged over the different information given about the sam-

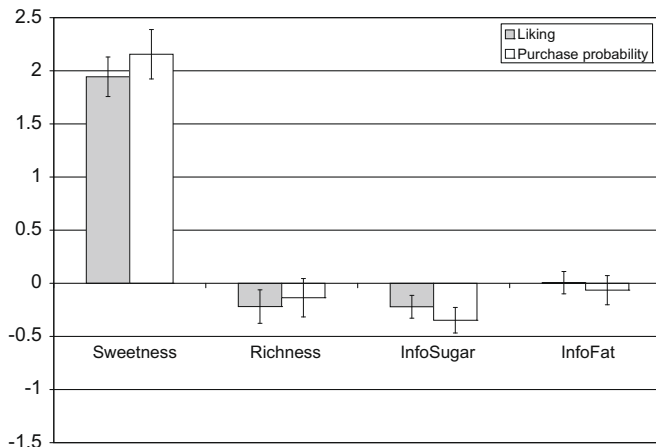


Fig. 5. The average effects of sweetness, richness, information about sugar content and information about fat content on liking and purchase probability. * P -value ≤ 0.05 .

ples fat content, as this effect was not significant (see Table 3). As can be seen, the sweetest yoghurts got the highest scores for acceptance (samples 6 and 12) even when information about high sugar content was given. An increase in richness only affected the least sweet samples resulting in a decrease in acceptance. The response to sample 6 differed from the responses to the other samples in the sense that it obtained the highest score value when presented without any information. For the other samples information in general increased the liking. For all the samples given information about low sugar content resulted in a higher degree of liking than given information about high sugar content.

The results from the PLS regression of the demographic and attitude variables (not shown) revealed no significant effect of these variables on hedonic liking or purchase probability of samples in informed conditions. This indicates no systematic relation between the preference pattern and consumer attitudes measured.

4. Discussion

In the present paper our main interest was to study acceptance of yoghurt with different levels of sweetness and richness, when corresponding information about sugar and fat content was given simultaneously with tasting.

We used sensory profiling as a basis for sample selection, to obtain yoghurt samples with a sensory profile which matched the nutritional information given. The focus on two pre-specified sensory attributes resulted in selecting four samples that created corners in a rectangle in Fig. 2 (sample 1, 6, 7 and 12). The sensory dimensions of main interest were called meta-attributes, in this case representing sweetness and richness. These meta-attributes were thus incorporated as “design factors” in the conjoint analysis. Before drawing final conclusions it is however important to remember that the meta-attributes are related to a number of other correlated sensory attributes which can be interpreted from the loadings plot. The effects of the sensory attributes and their combinations with extrinsic attributes were found using mixed model ANOVA.

4.1. Statistical methodology

The methodology proposed here is based on the idea that in many cases one is interested in the effects of the sensory attributes themselves, not in specific products. The advantages of the approach are that the selected samples span the sensory space, that

it allows to explicit focus on the sensory attributes of interest and that the selected samples combine easily in an experimental design with the extrinsic factors. The method can easily be extended to three or more sensory dimensions and to situations when no specific sensory properties are of particular interest a priori. In situations with no specific focus on pre-specified attributes, one will simply seek to establish a rectangular shape that covers the whole region as well as possible. In most cases it will be natural to select a rectangle that is parallel with the main PCA axes. In situations with three dimensions in the PCA plot, the rectangle generalises to a three dimensional rectangle (parallelepiped) with possibly different length of the axis in the three dimensions. The data obtained are in all these cases easy to analyse directly by the use of ANOVA. As can be seen from the results in this study, the method reveals information about the importance of all the four factors involved and also their interactions. As compared to established approaches in the area (Enneking et al., 2007; Helgesen et al., 1998) this is clearly a step forward. One may also use analysis of covariance methods with the principal component values for the samples used as covariates. This approach will be natural to use if it is difficult to find samples that resemble a rectangle as well as in the present study.

4.2. Effects of sweetness and richness

Even though the experimentally produced samples were tested and approved as representative for the Norwegian market by TINE BA before the experiment started, the general acceptance of these particular samples was unknown. Therefore it was of interest to obtain a “baseline” of acceptance when no information was given by conducting a blind testing. One important result from the blind testing was the dominating effect of sweetness on acceptance. This corresponds to earlier studies (Geiselman et al., 1998; Hayes & Duffy, 2008) and confirms our preference for sweetness (Desor, Maller, & Turner, 1973; Steiner, 1974). Moreover, an increase in the richness in the yoghurt samples only significantly increased acceptance for the sweetest yoghurts in the blind test. These results may relate to a synergistic effect with increased sucrose content on the oral perception of fattiness in the low-fat dairy products (Drewnowski & Greenwood, 1983; Drewnowski, Shrager, Lipsky, Stellar, & Greenwood, 1989; Tuorila et al., 1993).

Although the sensory quality of the tested samples was similar to existing products in the Norwegian market and therefore within realistic limits, the results from the blind test (i.e. the relatively large effect of sweetness on liking) indicated that the span in sweetness between samples was perceived as relatively large compared to the span in the richness. Results from the conjoint did show a relatively large increase in acceptance with increasing sweetness, i.e. increased sucrose content. Earlier studies on adults' hedonic ratings of sucrose sweetened dairy products have found that preference with increased sucrose concentration shows an inverted U shape where the optimal level of sucrose for females is at 10% and for males at 20% (Drewnowski & Greenwood, 1983; Monneuse, Bellisle, & Louissylvestre, 1991). In this study the variation in sugar concentration of the yoghurt samples was between 9% and 13% sucrose content, thus, in the part of the inverted U shape where an increase in preference (males) or a flattening out (females) was expected.

Tuorila et al. (1993) found that the most preferred combination of sugar and fat corresponded to the commercial yoghurts available in stores, thus the yoghurts consumed regularly. In the present study the most accepted yoghurts were the sweetest, containing 13% sucrose. In Norway the most dominating yoghurts on the market have 4% fat content and 16% sugar content. It is therefore likely that even though the participants were assumed to be health conscious consumers, they may not have been regu-

larly consumers of the yoghurt types with the most reduced sugar content, which may again explain their preference for the sweetest yoghurt.

4.3. Effects of information about fat and sugar content

Consumer acceptance was generally increased by giving information about low sugar content. The literature shows relatively few papers where the effect of giving information about the sugar content has been studied. Recently a study by Enneking et al. (2007) showed that calorie-reduced labelling increased the probability of choosing the soft drink. As a result of increased attention to negative effects of too much sugar in human diet and the relative novelty of sugar reduction labelling, positive effects of information about reduced sugar content may be expected (effects on acceptance and purchase probability). More studies are needed to confirm this hypothesis.

The conjoint did not show a significant effect of giving information about the fat content, although the subjects were assumed to have a relatively high interest in healthy eating. The effect of reduced-fat information has been studied thoroughly and diverse results have been found in the literature. Studies on ice cream and spread where reduced-fat information were given showed an increase in the subjects' hedonic liking compared to blind testing (Kähkönen et al., 1996; Light et al., 1992). A negative effect of giving reduced-fat information has been seen for cheese (Westcombe & Wardle, 1997) while no effect has been shown for yoghurt (Kähkönen et al., 1997; Westcombe & Wardle, 1997), corresponding with results from this study. Kähkönen et al. (1997) suggested that the reason for such a result might be that yoghurt originally is considered as a low-fat and healthy product.

The effect of information may depend on the product category but probably also on the type of information given. Concerning information about a relatively low-fat content, studies have shown that this in general reduces consumer expectations with regard to the sensory quality (Kähkönen & Tuorila, 1998; Tuorila, Cardello, & Leshner, 1994). Moreover, it is shown that consumers tend to assimilate towards their expectations (Anderson, 1973; Deliza & MacFie, 1996), to reduce the perceived inconsistency between product expectations and actual product performance. In the present study expected liking was not measured, making it difficult to draw any specific conclusions regarding the relation between blind testing, consumer expectations and informed testing.

4.4. The interaction effects

A significant interaction effect was found. This effect is a confounded effect between two possible interactions: sweetness \times richness and (information about sugar content) \times (information about fat content). As the main effect of information about the fat content was not significant in the conjoint and the interaction between sweetness and richness was significant in the blind test, it is likely that this effect is due to interaction between sweetness and richness. However, as always when using fractional designs, one needs more detailed experimentation addressing this particular problem to be able make more specific conclusions (see Box, Hunter, and Hunter (1978)).

No interaction effect was shown for the interactions sweetness \times (information about the sugar content) or richness \times (information about the fat content), although significant main effects for both sweetness and information about the sugar content were found for both hedonic liking and purchase probability. This indicates that the consumers did react to the information about sugar content but that it was independent of the sweetness level, thus it seems that the expectations created by the information resulted in the same rating no matter the product performance. An interesting

question is whether an interaction effect for sweetness and information about the sugar content would have been found if the relatively large span in sweetness (in acceptance) had not been observed.

5. Conclusions

This study shows that conjoint methodology is an appropriate tool to reveal the effects of specific intrinsic and related extrinsic product attributes. A new approach is proposed for design of such studies which is based on selecting samples from a PCA plot of sensory data. The advantages of the method are that emphasis is given to sensory properties instead of specific products and that it is relatively simple to set up the design and to analysis effects of sensory and extrinsic attributes. The study confirms the importance of sensory properties, especially sweetness, for consumers' acceptance of yoghurt. Nutritional information was shown to play a certain role, and it appeared that this effect was independent of the strength of the sensory attributes.

Acknowledgements

This work was part of the project "Low energy products and consumer preferences" and was financed by the Research Council of Norway (NFR) through the Grant 167928/110. The authors would like to acknowledge TINE BA, Norway, who contributed with yoghurt samples and allowed the use of data from the low fat dairy project. In particular we want to express our gratefulness to our colleges especially Øydis Ueland for good advice and recommendations during the preparation of the paper. In addition we want to thank the referees for their valuable comments regarding the paper.

References

- Aaron, J. I., Mela, D. J., & Evans, R. E. (1994). The influences of attitudes, beliefs and label information on perceptions of reduced-fat spread. *Appetite*, 22(1), 25–37.
- Anderson, R. E. (1973). Consumer dissatisfaction – Effect of disconfirmed expectancy on perceived product performance. *Journal of Marketing Research*, 10(1), 38–44.
- Ares, G., Gimenez, A., & Gambaro, A. (2008). Influence of nutritional knowledge on perceived healthiness and willingness to try functional foods. *Appetite*, 51(3), 663–668.
- Ares, G., Gimenez, A., & Gambaro, A. (2009). Consumer perceived healthiness and willingness to try functional milk desserts. Influence of ingredient, ingredient name and health claim. *Food Quality and Preference*, 20(1), 50–56.
- Barnes, D. L., Harper, S. J., Bodyfelt, P. W., & McDaniel, M. R. (1991). Prediction of consumer acceptability of yogurt by sensory and analytical measures of sweetness and sourness. *Journal of Dairy Science*, 74(11), 3746–3754.
- Box, G. E. P., Hunter, W. G., & Hunter, J. S. (1978). *Statistics for experimenters*. New York: John Wiley & Sons, Inc.
- Cardello, A. V. (1995). Food quality – Relativity, context and consumer expectations. *Food Quality and Preference*, 6(3), 163–170.
- Cardello, A. V., & Sawyer, F. M. (1992). Effects of disconfirmed consumer expectations on food acceptability. *Journal of Sensory Studies*, 7, 253–277.
- Deliza, R., & MacFie, H. J. H. (1996). The generation of sensory expectation by external cues and its effect on sensory perception and hedonic ratings: A review. *Journal of Sensory Studies*, 11(2), 103–128.
- Desor, J. A., Maller, O., & Turner, R. E. (1973). Taste in acceptance of sugars by human infants. *Journal of Comparative and Physiological Psychology*, 84(3), 496–501.
- Drewnowski, A. (1993). Individual differences in sensory preferences for fat in model sweet dairy products. *Acta Psychologica*, 84(1), 103–110.
- Drewnowski, A., & Greenwood, M. R. C. (1983). Cream and sugar – Human preferences for high-fat foods. *Physiology and Behavior*, 30(4), 629–633.
- Drewnowski, A., Shrager, E. E., Lipsky, C., Stellar, E., & Greenwood, M. R. C. (1989). Sugar and fat – Sensory and hedonic evaluation of liquid and solid foods. *Physiology and Behavior*, 45(1), 177–183.
- Duboc, P., & Mollet, B. (2001). Applications of exopolysaccharides in the dairy industry. *International Dairy Journal*, 11(9), 759–768.
- Enneking, U., Neumann, C., & Henneberg, S. (2007). How important intrinsic and extrinsic product attributes affect purchase decision. *Food Quality and Preference*, 18(1), 133–138.
- Geiselman, P. J., Smith, C. F., Williamson, D. A., Champagne, C. M., Bray, G. A., & Ryan, D. H. (1998). Perception of sweetness intensity determines women's hedonic and other perceptual responsiveness to chocolate food. *Appetite*, 31(1), 37–48.

- Ginon, E., Lohéac, Y., Martin, C., Combris, P., & Issanchou, S. (2009). Effect of fibre information on consumer willingness to pay for French baguettes. *Food Quality and Preference*, 20, 343–352.
- Green, P. E., & Rao, V. R. (1971). Conjoint measurement for quantifying judgmental data. *Journal of Marketing Research*, 8(3), 355–363.
- Green, P. E., & Srinivasan, V. (1978). Conjoint analysis in consumer research – Issues and outlook. *Journal of Consumer Research*, 5(2), 103–123.
- Green, P. E., & Wind, Y. (1975). New way to measure consumers judgments. *Harvard Business Review*, 53(4), 107–117.
- Grünert, K. G. (2003). Purchase and consumption: The interdisciplinary nature of analysing food choice. *Food Quality and Preference*, 14(1), 39–40.
- Haddad, Y., Haddad, J., Olabi, A., Shuayto, N., Haddad, T., & Toufeili, I. (2007). Mapping determinants of purchase intent of concentrated yogurt (Labneh) by conjoint analysis. *Food Quality and Preference*, 18(5), 795–802.
- Hayes, J. E., & Duffy, V. B. (2008). Oral sensory phenotype identifies level of sugar and fat required for maximal liking. *Physiology and Behavior*, 95(1–2), 77–87.
- Helgesen, H., Solheim, R., & Næs, T. (1998). Consumer purchase probability of dry fermented lamb sausages. *Food Quality and Preference*, 9(5), 295–301.
- IDF-Standard (1997). *International Dairy Federation Standard 99C. Sensory Evaluation of Dairy Products by Scoring – Reference Method. [International IDF Standard 99C:1997]*. Brussels: International Dairy Federation.
- ISO (1988). *International Standard 8589. Sensory Analysis – General Guidance for the Design of Test Rooms. [Ref. No. ISO 8589:1988 (E)]*. Genève: International Organisation for Standardisation.
- ISO (1993). *International Standard 8586–1. Sensory analysis – Methodology – general guidance for the selection, training and monitoring of assessors. [Ref. No. ISO 8586–1:1993 (E)]*. Genève: International Organisation for Standardisation.
- Jaeger, S. R. (2000). Uncovering cultural differences in choice behaviour between Samoan and New Zealand consumers: A case study with apples. *Food Quality and Preference*, 11(5), 405–417.
- Johnson, R. M. (1974). Trade-off analysis of consumer values. *Journal of Marketing Research*, 11(2), 121–127.
- Kähkönen, P., Hakanpää, P., & Tuorila, H. (1999). The effect of information related to fat content and taste on consumer responses to a reduced-fat frankfurter and a reduced-fat chocolate bar. *Journal of Sensory Studies*, 14(1), 35–46.
- Kähkönen, P., & Tuorila, H. (1998). Effect of reduced-fat information on expected and actual hedonic and sensory ratings of sausage. *Appetite*, 30(1), 13–23.
- Kähkönen, P., & Tuorila, H. (1999). Consumer responses to reduced and regular fat content in different products: Effects of gender, involvement and health concern. *Food Quality and Preference*, 10(2), 83–91.
- Kähkönen, P., Tuorila, H., & Lawless, H. (1997). Lack of effect of taste and nutrition claims on sensory and hedonic responses to a fat-free yoghurt. *Food Quality and Preference*, 8(2), 125–130.
- Kähkönen, P., Tuorila, H., & Rita, H. (1996). How information enhances acceptability of a low-fat spread. *Food Quality and Preference*, 7(2), 87–94.
- Kim, K., & Setser, C. S. (1980). Presentation order bias in consumer preference studies on sponge cakes. *Journal of Food Science*, 45(4), 1073–1074.
- Laccarino, T., Di Monaco, R., Mincione, A., Cavella, S., & Masi, P. (2006). Influence of information on origin and technology on the consumer response: The case of soppressata salami. *Food Quality and Preference*, 17(1–2), 76–84.
- Lawless, H., & Heymann, H. (1999). *Sensory evaluation of food. Principles and practices*. New York: Kluwer Academic/Plenum Publishers.
- Light, A., Heymann, H., & Holt, D. L. (1992). Hedonic responses to dairy-products – Effects of fat levels, label information, and risk perception. *Food Technology*, 46(7), 54–57.
- MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies*, 4(2), 129–148.
- Mardia, K. V., Kent, J. T., & Bibby, J. M. (1980). *Multivariate analysis*. London: Academic Press.
- Martens, H., & Martens, M. (2001). *Multivariate analysis of quality. An introduction*. Chichester: John Wiley & Sons.
- Martens, H., & Næs, T. (1989). *Multivariate calibration*. Chichester: John Wiley & Sons.
- Miyazaki, A. D., Grewal, D., & Goodstein, R. C. (2005). The effect of multiple extrinsic cues on quality perceptions: A matter of consistency. *Journal of Consumer Research*, 32(1), 146–153.
- Mojet, J., & Köster, E. P. (2005). Sensory memory and food texture. *Food Quality and Preference*, 16(3), 251–266.
- Monneuse, M. O., Bellisle, F., & Louissylvestre, J. (1991). Impact of sex and age on sensory evaluation of sugar and fat in dairy-products. *Physiology and Behavior*, 50(6), 1111–1117.
- Nielsen, H. B., Sonne, A. M., Grünert, K. G., Banati, D., Pollak-Toth, A., Lakner, Z., et al. (2009). Consumer perception of the use of high-pressure processing and pulsed electric field technologies in food production. *Appetite*, 52(1), 115–126.
- Oakes, M. E., & Slotterback, C. S. (2001). What's in a name? A comparison of men's and women's judgements about food names and their nutrient contents. *Appetite*, 36(1), 29–40.
- Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preference. *Food Technology, Symposium, September*, 9–14.
- Roininen, K., Lahteenmaki, L., & Tuorila, H. (1999). Quantification of consumer attitudes to health and hedonic characteristics of foods. *Appetite*, 33(1), 71–88.
- Schnettler, B., Vidal, R., Silva, R., Vallejos, L., & Sepulveda, N. (2009). Consumer willingness to pay for beef meat in a developing country: The effect of information regarding country of origin, price and animal handling prior to slaughter. *Food Quality and Preference*, 20(2), 156–165.
- Shepherd, R., Sparks, P., Bellier, S., & Raats, M. M. (1991/2). The effects of information on sensory ratings and preferences: The importance of attitudes. *Food Quality and Preference*, 3(3), 147–155.
- Solheim, R., & Lawless, H. T. (1996). Consumer purchase probability affected by attitude towards low-fat foods, liking, private body consciousness and information on fat and price. *Food Quality and Preference*, 7(2), 137–143.
- Stefani, G., Romano, D., & Cavicchi, A. (2006). Consumer expectations, liking and willingness to pay for specialty foods: Do sensory characteristics tell the whole story? *Food Quality and Preference*, 17(1–2), 53–62.
- Steiner, J. E. (1974). Discussion paper – Innate, discriminative human facial expressions to taste and smell stimulation. *Annals of the New York Academy of Sciences*, 237(SEP27), 229–233.
- Tuorila, H., Cardello, A. V., & Leshner, L. L. (1994). Antecedents and consequences of expectations related to fat-free and regular-fat foods. *Appetite*, 23(3), 247–263.
- Tuorila, H., Sommaridahl, C., Hyvönen, L., Leporanta, K., & Merimaa, P. (1993). Sensory attributes and acceptance of sucrose and fat in strawberry yoghurts. *International Journal of Food Science and Technology*, 28, 359–369.
- Urala, N., & Lahteenmaki, L. (2006). Hedonic ratings and perceived healthiness in experimental functional food choices. *Appetite*, 47(3), 302–314.
- van Trijp, H. C. M., & Schifferstein, H. N. J. (1995). Sensory analysis in marketing practice. Comparison and integration. *Journal of Sensory Studies*, 10(2), 127–147.
- Visschers, V. H. M., & Siegrist, M. (2009). Applying the evaluability principle to nutrition table information. How reference information changes people's perception of food products. *Appetite*, 52(2), 505–512.
- Wansink, B. (2003). Response to “measuring consumer response to food products”. Sensory tests that predict consumer acceptance. *Food Quality and Preference*, 14(1), 23–26.
- Westcombe, A., & Wardle, J. (1997). Influence of relative fat content information on responses to three foods. *Appetite*, 28(1), 49–62.

Paper IV

Effects of information about fat percentage on acceptance of low-fat cheese

Susanne Bølling Johansen^{a,b,1}, Margrethe Hersleth^{a,b}, Judith Narvhus^b, Jorun Øyaas^c and Tormod Næs^a

^a Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway

^b Department of Chemistry, Biotechnology and Food Science, Norwegian University of Life Sciences, NO-1430 Ås, Norway

^c TINE BA, P.O. Box 25, NO-0051 Oslo, Norway

Abstract

The main objective of this study was to investigate the effect of information about fat content on consumer acceptance of a selection of low-fat cheeses. Seventeen low-fat (5% - 17%) cheeses, either experimentally produced or available on the Scandinavian market, were evaluated by a trained panel using descriptive sensory analysis. Based on the results of the profiling, twelve cheeses were selected for the consumer study. The consumers (n=114) rated degree of liking for the cheeses, both without and with being given information concerning the cheeses' fat content. Principal component analysis revealed independence between the sensory profile and fat content of the cheeses. On average, the consumers preferred cheeses with a cream and acidic flavour and a fatty and sticky consistency. Generally, being given information about fat content had a negative effect on liking, only for the most sensory appealing cheeses was a tendency for positive effect was observed. Consumer segments with different responses to the interaction between sensory profile and information were found.

Keywords: Low-fat cheese, Dairy, Information, Preference, Consumer

¹ Corresponding author at: Nofima Mat AS, Osloveien 1, NO-1430 Ås, Norway
Tel.: +47-64-970482; fax: +47-64-970333.

E-mail address: susanne.johansen@nofima.no (S. Johansen).

1. Introduction

Obesity has reached pandemic proportions, with more than 1 billion adults being overweight (WHO, 2002), an increase that has especially occurred in the last two decades. As a consequence, authorities have attempted to reduce this trend using different initiatives. One important approach is to increase public knowledge of the calorie and nutrient composition of foods by providing various types of health information as nutritional labelling and claims, and food choice recommendations. Research has shown that this type of information may positively affect consumer acceptance of healthy foods (Helgesen, Solheim, & Næs, 1998; Kähkönen, Hakanpää, & Tuorila, 1999; Kähkönen & Tuorila, 1998; Kähkönen & Tuorila, 1999; Shepherd, Sparks, Bellier, & Raats, 1991/2; Westcombe & Wardle, 1997). A major aspect of food product satisfaction for calorie-reduced foods is, however, the sensory appeal, clearly demonstrated by Enneking, Neumann, and Henneberg (2007) and Johansen, Næs, Øyaas, and Hersleth (2010). Grünert (2003) has pointed out that product information is particularly important for first-time buyers, but that product satisfaction is the key for long term repurchase.

In the case of calorie-reduced products, both sensory and hedonic expectations generated by product information influence product acceptance and consumer satisfaction (Cardello, 1995; Cardello & Sawyer, 1992). Studies focusing on the effect of nutritional information on sensory expectations have shown that consumers often perceive fat reduced foods as having inferior sensory properties as compared to conventional products (Hamilton, Knox, Hill, & Parr, 2000; Kähkönen & Tuorila, 1998; Tuorila, Cardello, & Leshner, 1994).

Dairy products play a particularly important role in this nutritional context because of their relatively high fat content and their widespread use in many countries. Consequently, calorie-reduced dairy products have been introduced and this kind of products have already been on the market for many years. However, the sensory quality of low-fat cheeses has often been perceived as inferior to the original products resulting in lower consumer acceptance. Today the dairy industry is to a greater extent able to deliver calorie-reduced products with a sensory quality that meets consumer demands. This is particularly true for the cheeses which will be the products in focus in this paper.

Various results have been obtained regarding the effects of information about fat reduction on acceptance of cheeses. Light, Heymann, and Holt (1992) found a positive effect of such information on acceptance, whereas Westcombe and Wardle (1997) observed a negative effect on pleasantness ratings for cheese with fat reduction labels. In both studies, the cheeses were either the same product or products containing similar amounts of fat. Thus, the actual impact of fat reduction on the sensory perception of the cheeses was not included in the studies. In other studies, it has also been discussed and demonstrated that consumers may vary strongly in their response to information on a reduction in

calories. In for instance Hamilton et al. (2000), a distinction is made between health-conscious and taste-conscious consumers and it is discussed how this could have an effect on their response to information on calorie-reduction in a product.

The main objective of this study was to investigate the effect of providing information about fat content on consumer acceptance of a selection of low-fat cheeses. The cheeses selected represent a large variability both with respect to sensory properties and fat content, and cover the greater part of the Scandinavian low-fat cheese market. The main focus is on the average tendencies in the population of consumers considered, but individual differences were also studied using preference mapping methods. Relations between acceptance patterns and various consumer attributes measured by a questionnaire were investigated using regression analysis. The setup of the study makes it possible to study the impact of the combination of sensory properties and information about fat content.

2. Material and methods

The study consisted of three steps: 1) descriptive sensory analysis of 17 low-fat cheeses, 2) selection of 12 cheeses for the consumer study, and 3) a consumer study where each consumer scored six cheeses under blind and informed conditions.

2.1. Products

Overall, 17 semi-hard low-fat cheeses (from 5% to 17%) either experimentally produced or commercially available in Finland, Sweden or Norway (see Table 1) were evaluated. The cheeses cover a large portion of the market of these types of products in all of the three countries. All cheeses representing one variety came from the same production batch. Each cheese product was therefore treated as homogeneous in the statistical analysis.

2.2. Descriptive sensory analysis

The cheeses were evaluated by a trained panel of 11 assessors performing descriptive sensory profiling according to “Generic Descriptive Analysis” as described by Lawless and Heymann (1999). All assessors were tested, selected and trained according to ISO standards (ISO, 1993), and the sensory laboratory used followed the ISO standards (ISO, 1988). The assessors agreed upon 30 attributes describing the variation of the cheese variants (see Table 2). All attributes were evaluated on an unstructured line scale with labelled endpoints going from no intensity (value 1.0) at the left side to high intensity (value 9.0) at the right side. In a pre-test session, the assessors were trained in the use of the scale by testing products that were considered to be extreme for the selected attributes which were typical for the low-fat cheeses tested (products 1 and 6). The cheeses were served at a temperature of 17 °C in pieces of 50 g each. The assessors evaluated

the products at an individual pace using a computerized system for the direct recording of data (CSA Compusense v 5.24, Canada). Two replicates were performed by each assessor for each cheese product. All products and replicates were served in a randomized way.

2.3. Selection of products for consumer study

The selection of cheeses was done based on the two first principal components which in this case described enough of the variability to represent the major part of the sensory variation (PC1:61%, PC2:26%). Twelve cheeses were considered enough to span the space properly. Testing of 12 cheeses for each consumer in the same session should be avoided to minimize sensory fatigue and boredom. It was therefore decided to split the consumer group randomly in two and present only six different cheeses to consumers in the two groups (group 1: n=59; group 2: n=55) (see Table 1). The product selection criteria were as follows; 1) each product set should cover the sensory space as evenly as possible, 2) the company (TINE BA) who participated in this study wanted specific cheeses (products 1, 2, 3, and 5) to be included and 3) different fat levels should be represented in each product set. For some of the analyses below it will be assumed that the two randomly chosen consumer groups have similar acceptance patterns so that they can be considered as a whole in the statistical analysis.

2.4. Consumer study

The test included 114 consumers who met the following criteria: consumers of hard or semi-hard cheese (≥ 3 times a week), 20-50 years of age, residing in the eastern part of Norway and concerned about health issues. The latter criterion was based on degree of agreement with the following two statements: "I am concerned about health and nutrition when I buy and consume food from the grocery store" and "When it comes to food purchase in the grocery store, I usually choose the healthier alternative, i.e. I choose the product with fewer calories rather than the regular product". Responses to these two statements were measured on a five point scale going from completely disagree (1) to completely agree (5). In order to participate in the study the consumer had to completely agree (5) or highly agree (4) with both statements. Consumers were randomly assigned to one of the two product sets. Socio-demographic characteristics of the two consumer groups are provided in Table 3. Each consumer group (group 1: n=59; group 2: n=55) receive a product set consisting of six cheeses (see Table 1).

The consumer test consisted of four sessions: 1) a hedonic evaluation of products without information about the fat content in the cheeses. The consumers were welcomed, explained that the test was a part of a research project and that it included an acceptance test of different cheeses, 2) a 30 minutes break, 3) a hedonic evaluation of the same cheeses with true information about the fat content. Please note that no indication was given that the consumers tested the

same cheeses under blind and informed condition, and 4) collection of socio- and demographic data and attitudes towards relevant issues using different validated attitude scales (the food neophobia scale (Pliner & Hobden, 1992), the health and taste attitude questionnaire (Roininen, Lähteenmäki, & Tuorila, 1999) and the restrained eating scale (van Strien, Frijters, Bergers, & Defares, 1986)).

The hedonic evaluations were conducted using a modified version of the nine point hedonic scale by Peryam & Pilgrim (1957) to rate degree of liking. The modified scale was anchored with “Dislike Extremely” and “Like Extremely” and with a neutral centre point of “Neither Like nor Dislike”. The cheeses were served in an order which used a balanced design (Earthy, MacFie, & Hedderley, 1997; MacFie, Bratchell, Greenhoff, & Vallis, 1989), at a temperature of 12-14 °C in pieces of 100-125 g. The consumers use a cheese slicer to remove the first layer of cheese before tasting the next slice. When finished, each of the consumers received a gift card.

2.5. Statistical analysis

The descriptive sensory data were analyzed using both univariate (Statistix v8.1, Analytical Software, US) and multivariate data analysis (The Unscrambler v9.2, Camo AS, Norway). Analysis of variance (ANOVA, mixed model with interactions and with assessor effect and interactions considered to be random) was performed in order to identify the sensory attributes that differentiated between products.

The product set selection was based on a principal component analysis (PCA) of the sensory data (significant attributes, $p < 0.05$) with the average response over replicates and assessors (mean centred data, no standardisation) (Mardia, Kent, & Bibby, 1980). Full cross validation (Martens & Næs, 1989) was used for validation of the components.

The consumer data were analyzed with SAS software v9.1.3 (SAS Institute Inc., Cary, NC) and The Unscrambler v9.2 (Camo AS, Norway). To study significant differences in the average hedonic rating between blind and informed test for each cheese, the SAS PROC UNIVARIATE procedure using student's t test (μ_0 equals zero) was applied. The PROC MIXED in SAS was used to study significant differences between the ratings of the consumer segment using a model with segment and consumer (segment) as the effects.

External preference mapping was conducted using principal component regression (PCR). The PCR was used for the significant sensory attributes ($p < 0.05$) and consumer data represented by the differences between the informed and blind test. The consumers were plotted in the sensory map in addition to plus and minus signs for each of the samples in order to visualise where the response to fat information was generally positive and where it was negative. The acceptance

pattern in each of the quadrants, treated as segments, was analysed by bar plots. The differences in acceptance pattern were also investigated in relation to additional consumer attributes using PCR and chi-square homogeneity tests.

3. Results

3.1. Descriptive sensory analysis and product selection

Mixed model ANOVA was used to evaluate the importance of the various sensory attributes for distinguishing between the samples. All sensory attributes were found to be significant except *nutty odour*, *nutty flavour*, *sun odour*, *sun flavour* and *metallic flavour*. These five non-significant sensory attributes were excluded from further analyses.

The PCA plot of the significant sensory attributes for all 17 cheeses is shown in Fig. 1, with an indication of which samples were selected for the consumer study. The plot shows no clustering of the cheeses in relation to fat content. For instance sample 11 (17% fat) and sample 13 (10% fat) are located close to each other, while sample 9 (17% fat) and sample 15 (17% fat) are located far from each other. This indicates that the sensory properties had only a relatively weak relation to the fat content.

The first principal component accounts for 61% of the systematic variation in the data and the second principal component for 26%. PC1 primarily describes the variation in the attributes of texture and appearance. The more firm, rubbery and less white cheeses (samples 9 and 16) are located at one side and the softer, more fatty and whiter cheeses (samples 7, 13 and 15) on the opposite. The PC2 describes the variation in odour, flavour and taste. The generally appealing cheese attributes such as cream and acidic flavour (Ritvanen et al., 2005) are located at one side (samples 1 and 2), with the less appealing cheese attributes such as artificial flavour and bitter taste (samples 6 and 12) located on the other.

The product set selection for the consumer study was mainly based on variation in the first two principal components, but as mentioned in Section 2.3 other criteria also had to be fulfilled. The six cheeses selected for consumer group 1 were as follows: 2 (16% fat), 7 (15% fat), 12 (5% fat), 13 (10% fat), 15 (17% fat), 16 (10% fat), while consumer group 2 tested the following cheeses: 1 (16% fat), 3 (13% fat), 5 (10% fat), 6 (17% fat), 8 (5% fat), 9 (17% fat). Group 1 tested one Norwegian, one Finnish and four Swedish cheeses, while group 2 tested three Norwegian, one Finnish and two Swedish cheeses. As can be seen from Fig. 1, the sample sets for both consumer groups resemble each other with respect to the sensory properties and cover most of the region of interest.

3.2. Consumer testing

3.1.1. Direct comparison of average liking before and after information

Fig. 2 shows the average hedonic ratings for blind and informed testing of the 12 cheeses. A much larger variation exists in hedonic ratings between cheeses than within the same cheese evaluated blind and informed. Since fat content and sensory properties are only weakly related, this may indicate that at an overall level, the sensory properties are actually more important than information about fat content.

The average rating, in the blind test, ranged from 4.5 (sample 16) to 6.9 (sample 15), while in the informed test it ranged from 4.2 (sample 12) to 7.2 (sample 15). Except for three samples, the information on fat content generally had a negative impact on the hedonic rating. For example, sample 3 (13% fat) had an average score of 6.0 in the blind test, while in the informed test it was given an average score of 5.4. The results from the student's t-test are shown in Table 4. A tendency to a positive impact was only observed for the cheese with the highest score within each consumer group (samples 1 and 15) which had a fat content of 16% or 17%. These results may indicate that consumers tend to respond more positively to information when a product has a relatively high sensory acceptance. Note also, that the positive tendency is only observed for samples with a relatively high fat percentage. A significant negative difference ($p < 0.05$) in acceptance between the blind and informed condition was observed for sample 3 (13% fat) and sample 12 (5% fat). The difference in liking for sample 1 (16% fat) and sample 9 (17% fat) were, however, close to being significant at the same level. Please note that there is a large gap between the largest p -value of these two samples ($p = 0.07$) to the next p -value ($p = 0.22$).

3.1.2. Preference mapping of the differences

The external preference mapping based on the differences in responses between informed and blind conditions is shown in Fig. 3. Note that since external mapping is used, the fact that the two consumer groups tested two different sets of samples has no significance. In this study, it is simply assumed that the two consumer groups have similar response pattern to the differences in sensory properties, which is reasonable since the consumer group were randomly split (see Table 3 for a description of the two groups). Each consumer is represented by a point in the plot of Fig. 3. In addition, each of the samples is represented by a plus or minus sign according to whether the average effect of information is positive or negative.

Explained variance from the PCR was relative high, as the two first components describe 47% of the variation in differences between responses given in informed and blind conditions. The consumer plot indicates large individual differences in

response pattern, but there seems to be a certain tendency to a higher portion of consumers in the third quadrant (lower left) than in the other three quadrants. This means that relatively many consumers appreciated cheeses described by acidic flavour and creamy flavour as well as fatty and sticky consistency (Fig. 1). From the score plot in Fig. 3 it can be seen that this is the region where the three samples (two for groups 1 and one for group 2) with a positive response to fat information are located. The fact that the three samples with a positive effect of information are located close to each other in the third quadrant indicates that information about fat percentage has a positive effect for samples which are higher rated (Fig. 2) and have the properties shown in that quadrant (Fig. 1). This was also indicated in Fig. 2, but in that case the tendency was less clear since the differences were non-significant at 5% level (Table 4).

3.1.3. More detailed investigation of preference profile within segments

In order to visualise the differences in response pattern among different consumer segments and to analyse the relation to additional consumer attributes, we decided to compute the average response profiles of the different quadrants of Fig. 3. The average difference profiles for each of the quadrants in the external PREFMAP are shown in Fig. 4a-d and the results from the significance tests for each sample are shown in Table 5. Table 5 presents both the p -values for the differences between the segments for each sample separately in addition to the results from a post-hoc analysis (Tukey) for the samples with a p -value less than 0.05. Note that those samples for which there were significant differences between the consumer segments, are all located in the outer edge of the sample scattering in the correlation loadings plot (Fig. 3).

The most striking result from the profile plots, supported by the significance tests, is the large difference in response pattern. For instance, the two extreme samples concerning highest positive and negative effect (samples 1 and 12) change place in the quadrants 1 and 3. Sample 1 goes from the most positive to the most negative and vice versa. The consumer segment in quadrant 1 shows a more positive response to the 5% fat content information (sample 12) than the other three consumer segments (see Table 5). Also samples 6, 9 and 16 are evaluated to be significantly different in the four quadrants. These samples represent different levels of fat content and different sensory properties.

3.1.4. Relation between reaction pattern and consumer background data

The relations between consumer response and consumer background data (socio-demographic data and response to attitude scales) were investigated using multivariate data analysis, tabulation and chi-square homogeneity tests for each type of background data separately. No systematic relationships were shown between attitude data and differences in response between informed and blind conditions. The homogeneity tests could not be performed for all attributes since

the counts were too low for some of the cells. The lines for the cells with too low counts were eliminated from the significance tests.

Table 6 shows the socio-demographic distribution in percentage within each segment. As can be seen, there are some differences between the segments for some of the attributes. The most significant attributes were gender and household with a p -value equal to 0.07 for both (results not shown). The segment in quadrant 2 consists to a larger degree of males compared to the other segments. Also, the segments in quadrant 1 and 4 are to larger degree households without children.

4. Discussion

4.1. *Low fat cheeses in Scandinavia – sensory description*

The present study included a wide range of low-fat cheeses in Scandinavia. The sensory descriptive analysis showed that the texture and appearance properties accounted for the largest variation (61%) in the cheeses, and that 26% of the variation was related to differences in odour, flavour and taste. According to the definition of the sensory attribute fattiness (see Table 2), a correlation between this attribute and the fat content in the cheese could be expected. However, in Fig. 1 fattiness does not seem to have been strongly correlation with the actual fat content of the cheeses.

Looking closer at cheeses from each country, the largest variation in sensory profiles was seen for the Swedish cheeses (samples 6, 12, 15, and 16) whereas many of the Norwegian low-fat cheeses had relatively similar sensory profiles. The latter were described by relatively high scores for acidic flavour and cream flavour (samples 1, 2 and 4) and a relatively fatty and sticky consistency (samples 1, 4 and 5). Ritvanen et al. (2005) showed acidic and creamy flavours as well as sticky consistency to be important attributes for acceptance of cheese.

4.2. *Selection of samples for two consumer groups*

In the present study consumers were randomly divided into two groups which tested two separate sets of cheeses. The main reason for doing this was to avoid sensory fatigue and boredom and to be able to test a relatively large set of samples that cover the region better. A possible drawback is that the size of the consumer group for each sample was reduced. This splitting has no effect for the conducted preference mapping if the response pattern is similar for the two groups. In this case the splitting was done randomly and the relatively similar description of the consumer groups in Table 3 gives no reason to expect any differences in response pattern between the groups.

4.3. Blind testing of low-fat cheese

The consumers were not given any information concerning the fat content of the cheeses in the blind test. The results showed that only one cheese product (sample 16) was rated lower than the midpoint 5 (neither like nor dislike). The cheeses with the lowest scores (samples 9, 12 and 16), were all characterized by a relatively high degree of graininess, rubbery, firmness and hardness. The low-fat cheeses rated above a score of 6 (samples 1, 7, 13 and 15), were all characterized by a relatively high degree of acidic flavour and cream flavour, fattiness and stickiness. These results support the findings by Ritvanen et al. (2005), who studied consumer acceptance of full fat (23-34%) and reduced fat (10-20%) cheeses in the Finnish market. Ritvanen et al. (2005) found that cheeses appealing to consumers had a sticky consistency, a creamy, full, salty and acidic flavour. Even though the cheeses in the present study all had a relatively low fat content (5-17%), the average variation in hedonic rating was similar to the results in Ritvanen et al. (2005).

4.4. Informed testing of low-fat cheese

Providing information about fat content generally resulted in a decrease in liking of the cheeses, although this decrease was only significant for sample 3 (13% fat) and sample 12 (5% fat). With information given, three cheeses (samples 9, 12 and 16) were scored lower than the midpoint 5 (neither like nor dislike). These three cheeses were given the lowest hedonic scores in the blind test, and they were characterised by a grainy, rubbery, firm and hard consistency. Interestingly, they represented the entire range of fat contents tested (from 5% to 17% fat). Thus, regardless of the information (“high” or “low”) about the fat content, the informed rating was lower than in the blind condition. A tendency for a positive effect of information was only observed for the cheeses that received the highest hedonic ratings in the blind test, and only if the information referred to a fat content of 16% or more.

4.5. Consumer segments

The segments considered here were defined by the quadrants. This splitting was motivated by the fact that there were no obvious segments in the data set and by the fact that there was a tendency of contrast between quadrant 1 and the others with respect to the average results (indicated by the plus signs in Fig. 3).

There was large variability in the consumers’ individual response to the information about fat content, and this was partly driven by the sensory acceptance of the low-fat cheese. The participants in the test were consumers of cheese (≥ 3 times a week), however not necessarily consumers of low-fat cheese. The data (Table 6) revealed that only about 20% of the participants consumed low-fat cheese weekly. Despite this, the average hedonic ratings were in the upper

part of the liking scale, for the majority of the low-fat cheeses tested (both without and with information). The three highest rated cheeses, both without and with information, originated from all the three Scandinavian countries.

A recent study by Pohjanheimo and Sandell (2009) found correlation between Finnish consumers' response to information and their background characteristics. Our study was only able to detect tendencies of systematic relations between consumers' response to information and socio- and demographic data and none of them correlated to the attitude scales. This may be due to the character of the tested information as well as the choice of attitude scales. For instance Pohjanheimo and Sandell (2009) tested manufacturer's and brand name, and not nutritional information. Another point which may explain the lack of relation between responses in this study is that Norwegian consumers are less accustomed to health improved foods, including cheese with a very low fat content, compared to Finnish consumers.

5. Conclusion

The present study tested Scandinavian low-fat cheeses, with a range of sensory profiles. Individual differences were observed among the consumers with regard to sensory acceptance. However, the majority preferred cheeses with acidic flavour and cream flavour and a fatty and sticky consistency. The study found consumer segments that reacted differently to the information about fat content. On average, information about fat content had a negative effect on consumers' hedonic rating, except for the cheeses with the highest sensory acceptance. In addition, the results from informed condition showed a tendency to be dependent on the sensory properties of the cheeses.

Acknowledgements

This work was part of the project “Low energy products and consumer preferences”, and was financed by the Research Council of Norway (NFR) through the Grant 167928/I10. The authors wish to thank TINE BA, Norway, for allowing the use of data from the project.

References

- Cardello, A. V. (1995). Food quality: relativity, context and consumer expectations. *Food Quality and Preference*, 6(3), 163-170.
- Cardello, A. V., & Sawyer, F. M. (1992). Effects of disconfirmed consumer expectations on food acceptability. *Journal of Sensory Studies*, 7(4), 253-277.
- Earthy, P. J., MacFie, H. J. H., & Hedderley, D. (1997). Effect of question order on sensory perception and preference in central location trials. *Journal of Sensory Studies*, 12(3), 215-237.
- Enneking, U., Neumann, C., & Henneberg, S. (2007). How important intrinsic and extrinsic product attributes affect purchase decision. *Food Quality and Preference*, 18(1), 133-138.
- Grunert, K. G. (2003). Purchase and consumption: the interdisciplinary nature of analysing food choice. *Food Quality and Preference*, 14(1), 39-40.
- Hamilton, J., Knox, B., Hill, D., & Parr, H. (2000). Reduced fat products – Consumer perceptions and preferences. *British Food Journal*, 102(7), 494-506.
- Helgesen, H., Solheim, R., & Næs, T. (1998). Consumer purchase probability of dry fermented lamb sausages. *Food Quality and Preference*, 9(5), 295-301.
- ISO. (1988). *International Standard 8589. Sensory Analysis - General guidance for the design of test rooms*. (Ref. No. ISO 8589:1988 (E)). Genève: International Organisation for Standardisation.
- ISO. (1993). *International Standard 8586-1. Sensory analysis - Methodology - general guidance for the selection, training and monitoring of assessors* (Ref. No. ISO 8586-1:1993 (E)). Genève: International Organisation for Standardisation.
- Johansen, S. B., Næs, T., Øyaas, J., & Hersleth, M. (2010). Acceptance of calorie-reduced yoghurt: Effects of sensory characteristics and product information. *Food Quality and Preference*, 21(1), 13-21.
- Kähkönen, P., Hakanpää, P., & Tuorila, H. (1999). The effect of information related to fat content and taste on consumer responses to a reduced-fat frankfurter and a reduced-fat chocolate bar. *Journal of Sensory Studies*, 14(1), 35-46.
- Kähkönen, P., & Tuorila, H. (1998). Effect of Reduced-fat Information on Expected and Actual Hedonic and Sensory Ratings of Sausage. *Appetite*, 30(1), 13-23.
- Kähkönen, P., & Tuorila, H. (1999). Consumer responses to reduced and regular fat content in different products: effects of gender, involvement and health concern. *Food Quality and Preference*, 10(2), 83-91.
- Lawless, H., & Heymann, H. (1999). *Sensory Evaluation of Food: Principles and Practices*. New York, NY: Kluwer Academic/Plenum Publishers.
- Light, A., Heymann, H., & Holt, D. L. (1992). Hedonic Responses to Dairy-Products: Effects of Fat Levels, Label Information, and Risk Perception. *Food Technology*, 46(7), 54-57.
- MacFie, H. J., Bratchell, N., Greenhoff, K., & Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first-order carry-over effects in hall tests. *Journal of Sensory Studies*, 4(2), 129-148.
- Mardia, K. V., Kent, J. T., & Bibby, J. M. (1980). *Multivariate Analysis*. London, UK: Academic Press.

- Martens, H., & Næs, T. (1989). *Multivariate Calibration*. Chichester, UK: John Wiley & Sons.
- Peryam, D. R., & Pilgrim, F. J. (1957). Hedonic scale method of measuring food preference. *Food Technology, Symposium, September*, 9-14.
- Pliner, P., & Hobden, K. (1992). Development of a Scale to Measure the Trait of Food Neophobia in Humans. *Appetite*, 19(2), 105-120.
- Pohjanheimo, T., & Sandell, M. (2009). Explaining the liking for drinking yoghurt: The role of sensory quality, food choice motives, health concern and product information. *International Dairy Journal*, 19(8), 459-466.
- Ritvanen, T., Lampolahti, S., Lilleberg, L., Tupasela, T., Isoniemi, M., Appelbye, U., Lyytikäinen, T., Eerola, S., & Uusi-Rauva, E. (2005). Sensory evaluation, chemical composition and consumer acceptance of full fat and reduced fat cheeses in the Finnish market. *Food Quality and Preference*, 16(6), 479-492.
- Roininen, K., Lähteenmäki, L., & Tuorila, H. (1999). Quantification of Consumer Attitudes to Health and Hedonic Characteristics of Foods. *Appetite*, 33(1), 71-88.
- Shepherd, R., Sparks, P., Bellier, S., & Raats, M. M. (1991/2). The effects of information on sensory ratings and preferences: the importance of attitudes. *Food Quality and Preference*, 3(3), 147-155.
- Tuorila, H., Cardello, A. V., & Leshner, L. L. (1994). Antecedents and Consequences of Expectations Related to Fat-free and Regular-fat Foods. *Appetite*, 23(3), 247-263.
- van Strien, T., Frijters, J. E. R., Bergers, G. P. A., & Defares, P. B. (1986). The Dutch Eating Behavior Questionnaire (DEBQ) for Assessment of Restrained, Emotional, and External Eating Behavior. *International Journal of Eating Disorders*, 5(2), 295-315.
- Westcombe, A., & Wardle, J. (1997). Influence of Relative Fat Content Information on Responses to Three Foods. *Appetite*, 28(1), 49-62.
- WHO. (2002). *The World Health Report 2002 - Reducing Risks, Promoting Health Life*. Geneva: World Health Organization.

Table 1

Semi-hard cheeses tested in the case study.

Product no.	Fat content (%)	Country of origin	Tested by consumer group	Sample name used in the plots (Fig. 1 and 3)
1	16	Norway	1	1 _{16%}
2	16	Norway	2	2 _{16%}
3	13	Norway	1	3 _{13%}
4	16	Norway		
5	10	Norway	1	5 _{10%}
6	17	Sweden	1	6 _{17%}
7	15	Finland	2	7 _{15%}
8	5	Sweden	1	8 _{5%}
9	17	Finland	1	9 _{17%}
10	17	Finland		
11	17	Sweden		
12	5	Sweden	2	12 _{5%}
13	10	Sweden	2	13 _{10%}
14	10	Sweden		
15	17	Sweden	2	15 _{17%}
16	10	Sweden	2	16 _{10%}
17	17	Sweden		

Table 2

Descriptors of sensory attributes used in sensory profiling.

	Sensory attributes	Definition
<i>Aroma</i>	Acidic odour	Fresh sour/sweet fruit-like odour (fruit acids)
	Sour odour	Odour of vinegar
	Fermented sour odour	Odour of fermented milk
	Sweet odour	Odour of sugar
	Nutty odour ^a	Odour of hazelnuts or walnuts
	Artificial odour	Overall intensity of artificial odour in the sample
	Cream odour	Odour of cream
	Sun odour ^a	Odour of oxidised proteins
<i>Appearance</i>	Whiteness	Degree of white vs. black or colour in the sample (NCS-system)
	Hue	Degree of yellow vs. red in the sample (NCS-system)
	Chromaticness	Pure colour vs. shade of white and/or black in the sample (NCS-system)
<i>Flavour/ Taste</i>	Acidic flavour	Fresh sour/sweet fruit-like flavour
	Metallic flavour ^a	Metallic flavour
	Fermented sour flavour	Flavour of fermented milk
	Nutty flavour ^a	Flavour of hazelnuts or walnuts
	Artificial flavour	Overall intensity of artificial flavour in the sample
	Cream flavour	Flavour of cream
	Sun flavour ^a	Flavour of oxidised proteins
	Sweet taste	Taste of sweetness (sucrose)
	Salt taste	Taste of saltiness (sodium chloride)
	Bitter taste	Taste of bitterness (quinine or caffeine)
	Sour taste	Taste of sourness (organic acids)
	Aftertaste	Intensity of aftertaste after the sample no longer is present in the mouth (30 sec.)
<i>Texture/ Mouthfeel</i>	Astringent	Astringent mouthfeel
	Firmness	Assessed by cutting the cheese with a knife
	Hardness	Assessed with the molars at 1 st bite. The force required to bite through the sample
	Fattiness	Related to the amount of fat in the sample
	Graininess	Related to particle size and particle shape in the sample
	Stickiness	Related to a coherent, tough, glue-like sensation in the mouth
	Rubbery	Related to cohesion and at the time or the amount of chewing required to chew a solid product to a state ready for swallowing

^a Not significant.

Table 3

Composition of the consumer sample (n=114).

		Consumer group		Total
		1	2	
Gender	Female	29	35	64
	Male	26	24	50
Age	20-29	8	9	17
	30-39	18	19	37
	40-49	25	29	54
	50-59	4	2	6
Highest level of education	Elementary school	0	3	3
	Secondary school	18	13	31
	High school	19	25	44
	University	18	18	36
Household	Single	1	5	6
	Single with children	1	4	5
	Cohabitants	12	19	31
	Cohabitants with children	41	31	72
Body mass index [†]	Normal weight (18.5 - 24.9)	29	31	60
	Overweight (25.0 - 29.9)	17	22	39
	Obese (≥ 30)	7	6	13
Eat low-fat cheese [‡]	Weekly	11	13	24
	Monthly	22	29	51
	Seldom	22	16	38

[†] Missing data: One female and one male from group 1 did not reply on weight and height. [‡] Missing data: One male from group 2 did not reply.

Table 4

Effect of information on liking for all consumers (results from student's t-test). The samples are ordered by decreasing fat content. Samples with a *p*-value less than 0.1 are highlighted.

Sample	Effect of information on liking	<i>p</i> -value
6 _{17%}	-	0.73
15 _{17%}	+	0.22
9 _{17%}	-	0.06
2 _{16%}	+	0.77
1 _{16%}	+	0.07
7 _{15%}	-	0.24
3 _{13%}	-	0.04
13 _{10%}	-	0.28
5 _{10%}	-	0.48
16 _{10%}	-	0.33
8 _{5%}	-	0.36
12 _{5%}	-	0.02

Table 5

Effect on liking of being given information on fat content of cheese, shown for the four segments (results from ANOVA mixed model). Segment columns with different letters are significantly different at a 5% level.

Sample	<i>p</i> -value ^a	Segment in quadrant			
		1	2	3	4
6 _{17%}	0.01	ab	a	a	b
15 _{17%}	0.12				
9 _{17%}	0.01	a	a	b	a
2 _{16%}	0.07				
1 _{16%}	0.01	b	b	a	b
7 _{15%}	0.34				
3 _{13%}	0.07				
13 _{10%}	0.01	ab	a	b	b
5 _{10%}	0.20				
16 _{10%}	0.01	b	c	bc	a
8 _{5%}	0.55				
12 _{5%}	0.01	a	b	c	b

^a *P*-value of 0.01 means equal to or less than 0.01.

Table 6

Demographic profile of the four consumer segments who responded differently to the nutritional information.

		Segment in quadrant (%)			
		1	2	3	4
Gender	Female	69	37	67	59
	Male	31	63	33	41
Age	20-29	19	9	12	17
	30-39	38	40	24	31
	40-49	44	46	55	52
	50-59	0	9	9	0
Highest level of education	Elementary school	0	6	3	0
	Secondary school	25	26	24	34
	High school	38	31	42	45
	University	38	40	30	21
Household	Single	13	0	6	7
	Single with children	0	6	6	3
	Cohabitants	38	25	12	41
	Cohabitants with children	50	69	76	48
Body mass index [†]	Normal weight (18.5 - 24.9)	63	49	61	45
	Overweight (25.0 - 29.9)	31	46	24	34
	Obese (≥ 30)	6	9	15	14
Eat low-fat cheese [‡]	Weekly	19	19	27	17
	Monthly	56	44	30	55
	Seldom	25	36	39	28

[†] Missing data: One female and one male from group 1 did not reply on weight and height. [‡] Missing data: One male from group 2 did not reply.

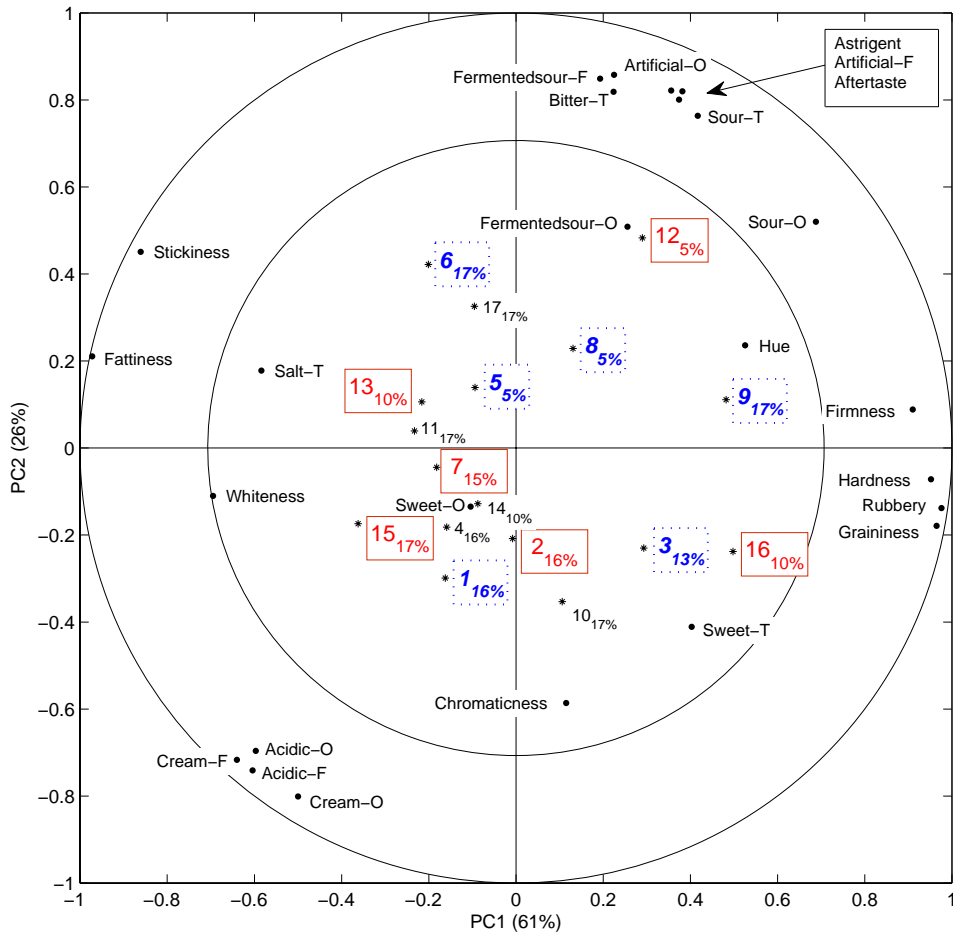


Fig. 1. PCA correlation loadings plot for the two first components showing the significant sensory attributes (p -value < 0.05) for the 17 cheeses. Cheese samples served to consumer group 1 are marked with a dashed square; Cheese samples served to consumer group 2 are marked with a solid square. Labels (*) and (•) indicates products and sensory attributes, respectively. F: flavour, O: odour, T: taste.

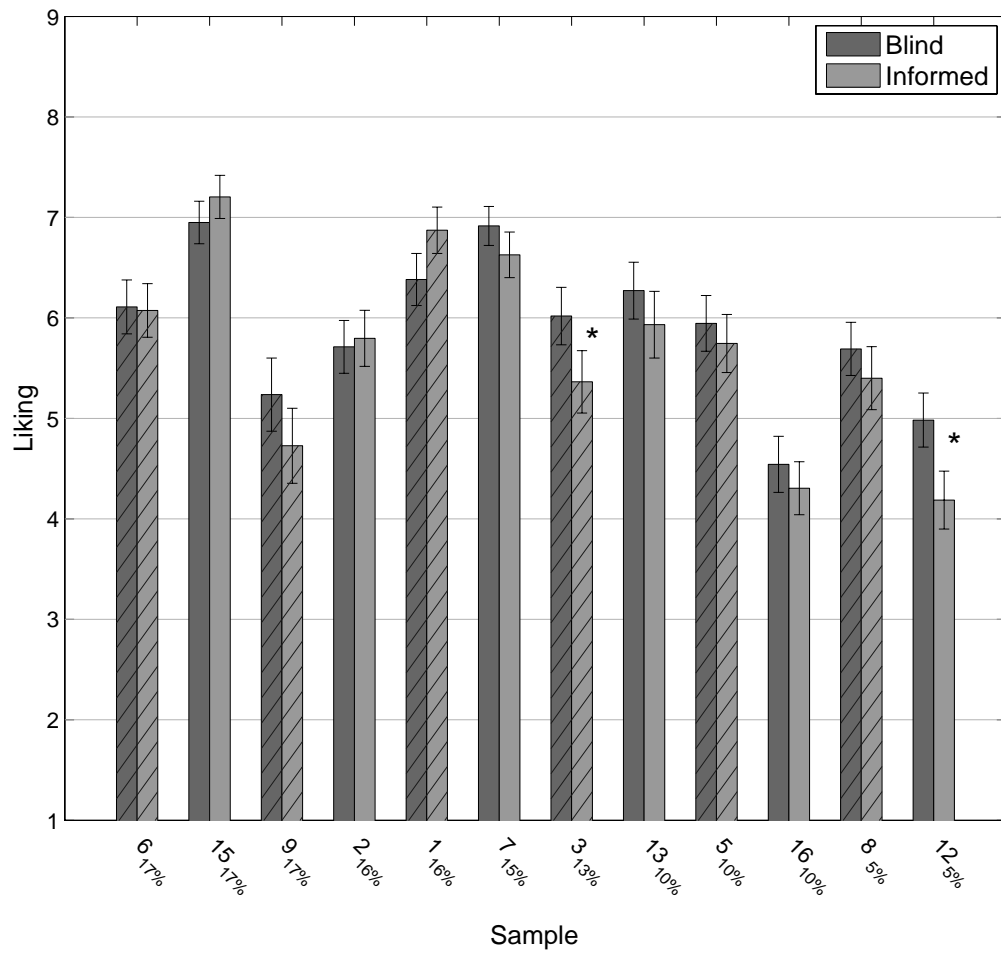


Fig. 2. Average hedonic liking for all 12 cheeses tested blind and with information about percent fat content. Columns are sorted according to decreasing fat percentage. Hatched bars represent samples served to consumer group 1. Standard error of the mean (SEM) is shown for each bar. Samples with a significant difference for liking between blind and informed conditions are indicated (* p -value < 0.05).

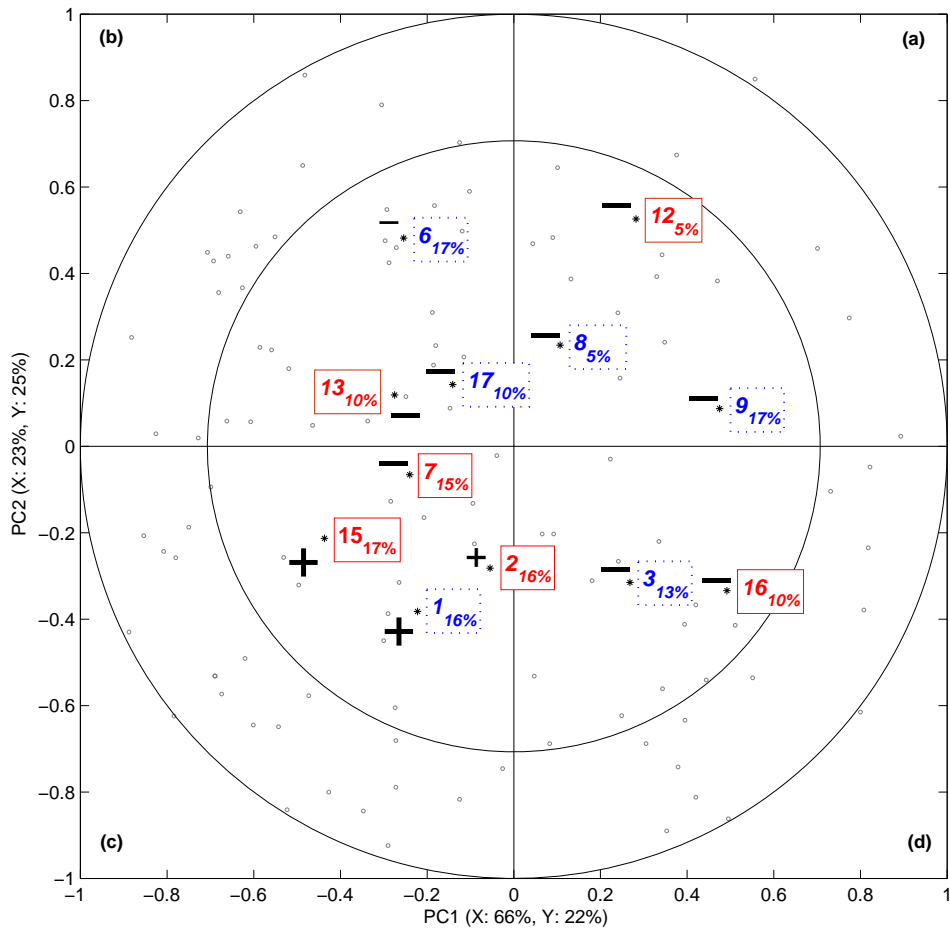


Fig. 3. External PREFMAP (PCR) of the difference in responses between blind and informed tests, for all the consumers. Labels (+) or (-) represents average increase or decrease in liking when consumers were given information about percent fat content. Labels (*) and (o) indicates products and consumers, respectively.

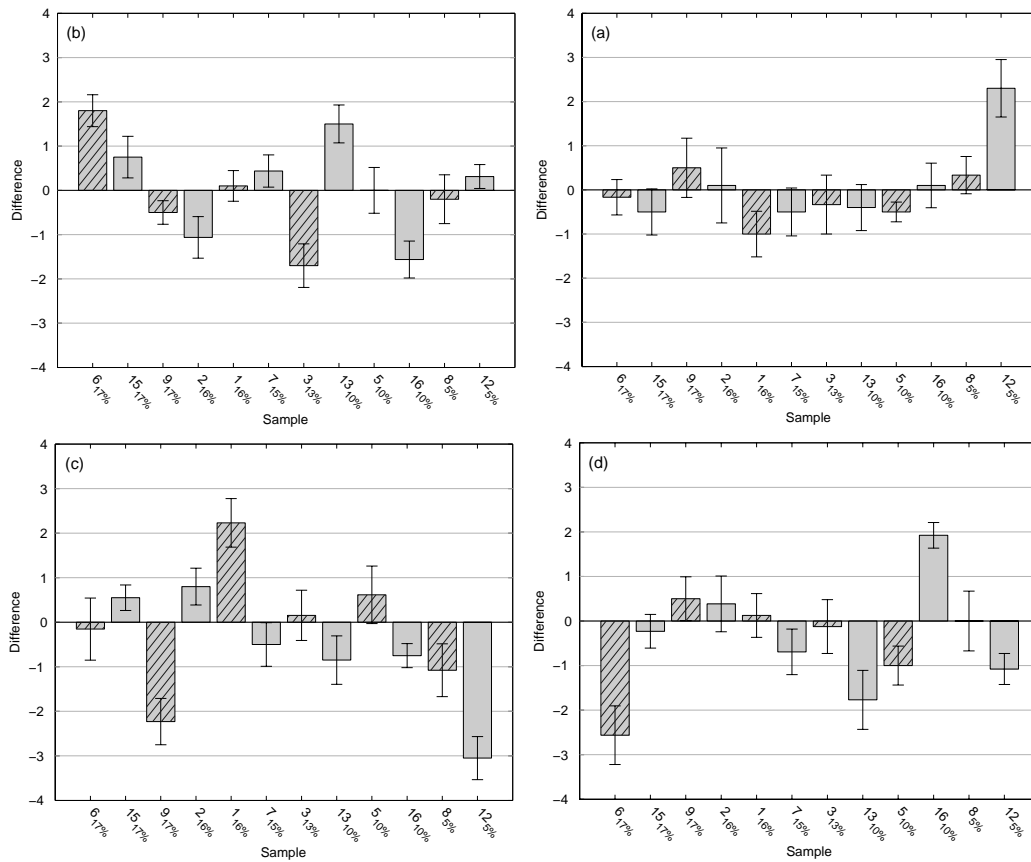


Fig. 4. The difference in hedonic liking between blind and informed testing for all 12 cheeses. Fig. 4a-d represents the consumer profiles from each of the four quadrants in Fig. 3 ((a) quadrant 1: n=16, (b) quadrant 2: n=36, (c) quadrant 3: n=33, (d) quadrant 4: n=29). Hatched bars represent results for consumer group 1. Standard error of the mean (SEM) is shown for each bar.