



Sensory factors in food satisfaction. An understanding of the satisfaction term and a measurement of factors involved in sensory- and food satisfaction

Andersen, Barbara Vad; Hyldig, Grethe; Jørgensen, Bo Munk

Publication date:
2014

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Citation (APA):

Andersen, B. V., Hyldig, G., & Jørgensen, B. M. (2014). Sensory factors in food satisfaction. An understanding of the satisfaction term and a measurement of factors involved in sensory- and food satisfaction. Kgs. Lyngby: Technical University of Denmark (DTU).

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Sensory factors in food satisfaction. An understanding of the satisfaction term and a measurement of factors involved in sensory- and food satisfaction.

Barbara Vad Andersen
PhD Thesis
2014

National Food Institute, Technical University of Denmark

Title:

Sensory factors in food satisfaction. An understanding of the satisfaction term and a measurement of factors involved in sensory- and food satisfaction.

Main supervisor:

Senior scientist Grethe Hyldig

National Food Institute, Department of Industrial Food research, Technical University of Denmark, Denmark

Co-supervisor:

Senior scientist, Bo Munk Jørgensen

National Food Institute, Department of Industrial Food research, Technical University of Denmark, Denmark

Opponents:

Karin Wendin

Erminio Monteleone

Date of PhD defence

27.02.15

ACKNOWLEDGEMENTS

This thesis is submitted in partial fulfilment of the requirements for the degree of Doctor of Science at the national food institute, Technical University of Denmark.

It is the result of three inspiring years of work on the SENSWELL project funded by Innovation Fund Denmark (grant no. 0603-00418B).

All this work could not have been done without the help and support from people around me. A special thanks goes to my main supervisor, *Grethe Hyldig*, with whom I have had many fruitful discussions throughout all phases of my PhD. Grethe, very fast you created a solid basis where I could feel safe and from which I could develop, for that I am truly grateful. Despite the frustrating and confusing environment that has surrounded my time as a PhD student, you have always believed in me. It has helped me to enjoy every single phase.

I also wish to thank *Per B. Brockhoff* who helped me with statistical analysis, *Jos Mojet* and *Bo Jørgensen* for your advices during the PhD.

Beside the team of advisors I would also like to thank the rest of the *SensWell partners* for inspiring meetings and collaborational work, especially the team at *Aarhus University, department of food science* and *University of Copenhagen, department of food science*. It has been a pleasure working with you. Thanks to the industry partners TINE and Rynkeby, *Hilde Kragerud* and *Leslie L. Jørgensen* for warmly welcoming me to your facilities and providing products for my studies. I am grateful that we got to collaborate.

I would like to thanks all the consumer groups in Norway and Denmark, who were involved as test persons in my studies, and made all of this possible.

Finally, I have received a tremendous support from family and friends, especially my husband *Victor* and children *Rebecca* and *Benjamin*. I am grateful for your patience with me and my research. This has been absolutely essential for completing the project. Though I never get tired of working on this project, I do indeed look forward to spending more time with you.

Barbara Vad Andersen
Lyngby
December 2014

ABSTRACT

Satisfaction is suggested as a holistic response variable when measuring consumers' hedonic food appreciation. However, "satisfaction" is a relatively new term within sensory science research. Thus, knowledge is needed about how to interpret the term, and about which factors that influence consumers' degree of intake related food satisfaction. The main purposes of this PhD project were:

- 1) to contribute with a theoretical understanding of "food satisfaction" to be used prospectively within sensory science research
- 2) to develop a method measuring: consumers' degree of intake related satisfaction and factors influencing food satisfaction
- 3) to use the method in case studies

Definitions of "satisfaction" which previously had been used within sensory science were analysed according to three factors; type of response, focus in the response and timing of the response. The analysis showed that "satisfaction" could be regarded an affective response to food. The focus of the response varied between definitions. In addition to focus on the intake experience, the food was evaluated based on intake induced physical- and psychological well-being related sensations, and the context in which the food was eaten. The timing of the response varied between definitions. One definition did not imply when to measure satisfaction, others implied that satisfaction could be measured after intake. The analysis of the satisfaction terms was employed to develop working definitions of satisfaction which should be used prospectively in the PhD project; a definition of "sensory satisfaction" and a definition of "food satisfaction". In "sensory satisfaction" focus was on the foods sensory properties. The definition of "food satisfaction" could be regarded "broader" in the sense that a holistic approach was used. The food was evaluated with focus on the context in which it was consumed, and intake related physical- and psychological sensations.

Focus group interviews were used to initiate the study of factors influencing food satisfaction among consumers. Results from the focus group studies showed that factors within the categories "product", "person" and "context" influenced consumers' degree of "food satisfaction". Further, a temporal perspective was indicated, regarding when each factor was relevant for food satisfaction. Some factors were present before intake, whereas others became relevant during- and after intake. The results from the focus group interviews formed the basis of the development of a set of questionnaires; to be answered by consumers before-, during- and after food intake. The development questionnaires were further based on: the work on analysing the satisfaction terms and a model of factors affecting food choice and behaviour, developed by Jos Mojet. In addition to measure consumers degree of "sensory-" and "food satisfaction" the questionnaires were used to measure factors influencing "food satisfaction". The questionnaires were developed so that they could be applied on a broad range of foods.

The set of questionnaires were used in three product cases; a consumer study on creamy chicken soups, a consumer study on yoghurt with/mueslis, conducted in a lab context and a natural context respectively, and a consumer study on cherry-apple fruit drinks. The study on creamy chicken soups utilised the original set of questionnaires. For the study on yoghurt with/mueslis, an extra

questionnaire was included, to measure influential factors in food satisfaction one hour after intake. Finally, for the study on fruit drinks, a set of questionnaires were developed with increased focus at physical well-being related sensations.

Objective sensory analysis was conducted on products included in each consumer study. To study sensory attributes influential in sensory satisfaction, the results from sensory analysis was related consumers rating of “sensory satisfaction”.

In each consumer study, data was analysed to find factors influential in food satisfaction. Overall, the consumer studies showed that factors within the classifications: “product-person interrelated-“, “person related-” and “context related-” factors, influenced food satisfaction. Though the concrete factors varied between studies, several factors were repeatedly found influential in food satisfaction. Among those were: “sensory satisfaction”, “reason for ending intake”, “hunger”, “fullness”, “product performance compared to expectations”, “general liking of food type”, “energy level after intake”, “age” and “BMI”.

This PhD project contributes with a theoretical description and discussion of; the terms “sensory satisfaction” and “food satisfaction”, how the terms can be used within sensory research and influential factors in food satisfaction. “Sensory satisfaction” can be used as an alternative to the traditionally used response variable “overall liking”, where focus is at the hedonic experience of the foods sensory properties. However, more studies are needed to clarify how “sensory satisfaction” is different from “overall liking”. “Food satisfaction” can be used as a holistic term for food appreciation. In order to be able to generalise the results found in the present PhD project, studies are needed which utilise a broader range of products within the same food category, as well as studies that compare results between food categories.

SAMMENDRAG

Tilfredsstillelse er foreslået som et holistisk respons ved måling af forbrugeres hedoniske opfattelse af fødevarer. "Tilfredsstillelse" er dog et relativt nyt begreb indenfor sensorisk forskning. Derfor er der behov for viden om, hvordan begrebet kan defineres, samt om hvilke faktorer der påvirker, hvorvidt forbrugere bliver tilfredsstillede af de fødevarer/drikkevarer de indtager. Formålet med dette PhD projekt var:

- 1) at bidrage med en teoretisk forståelse af begrebet "tilfredsstillelse" til anvendelse indenfor sensorisk forskning
- 2) at udvikle en metode til at måle; forbrugeres grad tilfredsstillelse ved indtag af fødevarer samt faktorer af betydning for tilfredsstillelse
- 3) at anvende metoden i konkrete case studies

Tidligere anvendte definitioner af "tilfredsstillelse" blev analyseret ud fra tre faktorer; typen af respons, fokus for responset og hvornår responset blev målt. Analysen viste, at "tilfredsstillelse" blev betragtet som et affektivt respons til en fødevarer. Fokus for responset varierede afhængig af definition. Foruden at være fokuseret på selve indtags oplevelsen blev fødevareren vurderet ud fra de fysiske- og psykiske fornemmelser der opstod i forbindelse med indtag samt ud fra den kontekst fødevareren var en del af. Hvornår "tilfredsstillelse" blev målt varierede ligeledes imellem definitionerne. Hvor én definition ikke antydede direkte hvornår "tilfredsstillelse" kunne måles, blev der i andre definitioner lagt op til, at "tilfredsstillelse" blev målt efter indtag. Analysen af de tidligere definitioner for "tilfredsstillelse" blev anvendt til at udarbejde to arbejdsdefinitioner til videre anvendelse i projektet; én for "sensorisk-tilfredsstillelse" og én for "fødevarer-tilfredsstillelse". I definitionen af "sensorisk-tilfredsstillelse" var fokus på tilfredsstillelse på baggrund af fødevarerens sensoriske egenskaber. Definitionen af "fødevarer-tilfredsstillelse" var bredere i den forstand, at den ikke fokuserede på enkelte faktorer men havde en holistisk tilgang, hvor fødevareren blev vurderet ud fra den kontekst den indgik i samt de fysiske- og psykiske fornemmelser der var forbundet med indtag.

Fokusgruppe interviews indledte studierne af, hvilke faktorer der influerede forbrugeres tilfredsstillelse. Fokusgrupperne viste, at faktorer indenfor de tre kategorier; produkt, person og kontekst alle påvirkede forbrugernes grad af tilfredsstillelse. Derudover var der en tidsmæssig forskel i, hvornår de enkelte faktorer var relevante. Fokusgruppestudierne dannede delvist grundlag for udarbejdelsen af et basis-sæt af spørgeskemaer, som blev delt ud til forbrugerne hhv. før-, under- og efter indtag. Udover resultater fra fokusgruppestudiet, blev arbejdet med forståelsen af tilfredsstillelses-begreberne, samt en model udviklet af Jos Mojet over faktorer af betydning for fødevarer valg og adfærd også anvendt i udarbejdelsen af spørgeskemaerne. Foruden at måle forbrugeres grad af "sensorisk-" og "fødevarer-tilfredsstillelse" blev der i spørgeskemaerne også målt faktorer af betydning for "fødevarer-tilfredsstillelse". Spørgeskemaerne blev udviklet, så de kunne anvendes på en bred række af føde- og drikkevarer.

Spørgeskemaerne blev anvendt i tre product-cases; et forbrugerstudie på cremede hønsekødssupper, et forbrugerstudie på yoghurt m/mysli som dels blev gennemført i en laboratorie- og en naturlig

kontekst, samt et forbrugerstudie på æble-kirsebær frugtdrikke. Til hønsekødssuppe-studiet blev basis sættet af spørgeskemaerne anvendt. Til yoghurt studierne blev et spørgeskema efter en time inkluderet, for at undersøge faktorer af betydning for tilfredsstillelse en time efter indtag. Og, til studiet på frugt drikke blev der udarbejdet et sæt spørgeskemaer med øget fokus på fysiske fornemmelser tilknyttet velvære efter indtag.

I relation til hvert forbrugerstudie blev der gennemført objektiv sensorisk analyse af de anvendte produkterne. Resultaterne fra de sensoriske analyser blev sammenholdt med forbrugerens vurdering af ”sensorisk tilfredsstillelse”, og viste hvilke attributter der var associeret til ”sensorisk tilfredsstillelse”.

For hvert forbrugerstudie blev data analyseret, for at finde frem til hvilke faktorer der influerede på ”fødevare-tilfredsstillelse”. Generelt set viste forbrugerstudierne, at faktorer indenfor kategorierne: ”produkt-person inter-relaterede-”, ”person relaterede-” og ”kontekst relaterede” faktorer influerede ”fødevare-tilfredsstillelse”. På trods af at de konkrete faktorer varierede imellem studierne, blev flere faktorer gentagne gange fundet at influere ”fødevare-tilfredsstillelse”. Iblandt de konkrete faktorer var bl.a.: ”sensorisk-tilfredsstillelse”, ”årsag til endt indtag”, ”appetit”, ”produkt præstation i forhold til forventning”, ”at kunne lide fødevarer generelt”, ”energi niveau efter indtag”, ”alder” og ”BMI”.

Dette PhD projekt bidrager med en teoretisk beskrivelse og diskussion af; begreberne ”sensorisk-” og ”fødevare-tilfredsstillelse”, hvordan begreberne kan anvendes i sensorisk forskning/forbrugerstudier, samt hvilke faktorer der påvirker ”fødevare-tilfredsstillelse”. ”Sensorisk-tilfredsstillelse” kan anvendes som et alternativ til den traditionelt anvendte responsvariabel, ”overall liking”, hvor der er fokus på den hedoniske opfattelse af fødevarens sensoriske egenskaber. Flere studier er dog påkrævet for at vise, hvordan ”sensorisk-tilfredsstillelse” adskiller sig fra ”overall liking”. ”Fødevarer-tilfredsstillelse” kan anvendes som et holistisk begreb for værdsættelse af fødevarer. For at kunne generalisere de fundne resultater, er der behov for studier der anvender flere fødevarer indenfor samme fødevarerkategori, og som sammenligner resultater heraf med studier på andre fødevarer kategorier.

LIST OF PAPERS

The following papers are developed in relation to the PhD project:

Paper I: Consumers' view on determinants to food satisfaction. A qualitative approach

Barbara Vad Andersen & Grethe Hyldig

Submitted to Appetite, September 2014

Paper II: Food satisfaction: Integrating feelings before, during and after food intake

Barbara Vad Andersen & Grethe Hyldig

Submitted to Food Quality and preference, September, 2014

Paper III: The effect of protein content and study context on consumers' rating of hunger, fullness and food satisfaction. A case study using yoghurt with muesli products.

Barbara Vad Andersen, Hilde Kraggerud, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

Paper IV: Peri- and post intake drivers of satisfaction with yoghurt with/muesli products

Barbara Vad Andersen, Hilde Kraggerud, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

Paper V: Factors important for sensory satisfaction and food satisfaction after intake of fruit drinks varying in sweetener and addition of aroma and fibres

Barbara Vad Andersen, Line Holler Mielby, Ida Viemose, Wender L.P. Bredie & Grethe Hyldig

Draft, to be submitted

Paper VI: The relation between liking of sensory properties and sensory satisfaction. A comparison to overall liking.

Barbara Vad Andersen, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
FS	Food Satisfaction
<i>P</i>	Paper
PCA	Principal Component Analysis
PLSR	Partial Least Square Regression
Q ² cum	Cumulated Q ² quality index; the global contribution of the h first components to the predictive quality of the model
S	Study
SENSWELL	Sensory wellbeing. Sensory food satisfaction in promoting healthy and sustainable eating behaviour
SS	Sensory Satisfaction
VIP	Variables important in projection

Table of Contents

CHAPTER 1: INTRODUCTION	11
1.1 Project hypothesis and tasks	12
1.2 The PhD projects five phases	13
1.3 Chapters in the thesis	14
1.4 Overview of studies and papers	15
CHAPTER 2: UNDERSTANDING THE SATISFACTION TERMS; SENSORY SATISFACTION AND FOOD SATISFACTION	20
2.1 How has satisfaction been understood and defined previously?	20
2.2 How to understand sensory- and food satisfaction in relation to present PhD project?	22
CHAPTER 3: DEVELOPMENT OF A VOCABULARY OF FACTORS POTENTIALLY AFFECTING FOOD SATISFACTION	24
3.1 Overview of factors potentially affecting food satisfaction	24
3.2 Temporal perspective.....	27
3.3 Differences between questionnaires applied in the present PhD project.....	28
CHAPTER 4: MEASURING AND ANALYSING FOOD SATISFACTION	29
4.1 Measuring food satisfaction using focus groups	29
4.2 Analysis of focus group interviews	30
4.3 Measuring food satisfaction using questionnaires	30
4.4 Analysis of questionnaire data.....	31
CHAPTER 5: FACTORS INFLUENTIAL IN FOOD SATISFACTION	33
5.1 Product related factors.....	37
5.1.1 Product characteristics and sensory differences of importance in SS and FS	37
5.2 Product-person interrelated factors	41
5.2.1 The importance of liking of: appearance, odour, taste and texture in sensory satisfaction	42
5.2.2 The influence of sensory satisfaction in food satisfaction.....	42
5.2.3 Reason for ending a meal	44
5.2.4 Expectations and product performance relative to expectations	44
5.3 Person related factors	50
Table 8. Overview of person related determinants to food satisfaction studied in the respective quantitative studies	50
5.3.1 Age.....	50
5.4 Context related factors.....	52

5.4.1 Test location	53
5.4.2 Social effects.....	54
5.4.3 Appropriateness	55
CHAPTER 6: SENSORY SATISFACTION VS. OVERALL LIKING	57
CHAPTER 7: CONCLUSION.....	59
CHAPTER 8: PERSPECTIVES	61
REFERENCES.....	63
APPENDIX 1: QUESTIONNAIRES	70
APPENDIX 2:MODEL OF FACTORS AFFECTING FOOD CHOICE AND BEHAVIOUR	Error! Bookmark not defined.
APPENDIX 3: PAPERS	Error! Bookmark not defined.

CHAPTER 1: INTRODUCTION

The Western diet contains food which are highly palatable, have a relatively high energy density and low content of fibres. These foods are believed to be major contributors to the growing obesity epidemic (e.g. Popkin, 2011; Rolls, 2009). To reduce the prevalence of obesity, low calorie alternatives can replace the energy dense foods (B. J. Rolls, 2009). However, this may not be the most optimal and sustainable strategy, as the sensory eating experience might be changed and the general food enjoyment suffer. An alternative strategy is, to investigate what gives people satisfaction with food, and use the knowledge to contribute to more healthy and sustainable eating practices. This is the main idea behind the SENSWELL project, which the present PhD is a part of.

Different approaches have been used to study drivers to eating behaviour and intake. Among those are studies of satiety. The role of food-type, volume, weight, macronutrient composition and fibre in relation satiation and satiety have been studied previously (e.g. Gerstein et al, 2004; Green & Slavin; 2007) and suggested, how we can use these factors to affect intake through satiety and satiation. The sensations commonly referred to when initiating eating or drinking are “hunger”, “thirst” and “desires”, whereas feelings of “satiation” are used later (e.g. Cardello et al, 2009; Murray & Vickers, 2009). However, these sensations do not account for the quality of the eating experience. To measure the hedonic perception of products, “liking” has often been used (Lim, 2011). Previous studies have found that liking of sensory properties played a huge role in food selection and intake (Cardello, 1996; Drewnowski & Hann, 1999; Fürst et al , 1996; Connors et al, 2001; Mojet, 2007). Other studies have investigated the context of consumption and found that intake and hedonic appreciation of food depended on the context in which the food was presented (e.g. de Graaf et al., 2005; King et al., 2004; H. L. Meiselman et al., 2000).

These findings demonstrate that the consumer’s impression of the food experience is affected by various factors. A combined measure for several of these factors could potentially explain more of consumers eating behaviour than each of these alone. Cardello and colleagues (2000) suggested “satisfaction”, a traditional measure within marketing, as a generalised response to foods. They state that the term might imply something about the foods value, its utility, or its adequacy for the situation. In their study it was shown that “satisfaction” was a better measure to predict consumption than the usual measures (e.g. preference), and acknowledged that more research was needed on satisfaction construct.

These findings suggest satisfaction as a multidimensional concept, covering different aspects of the consumers experience with food consumption, inclusive the context in which consumption takes place. In order to be able to use satisfaction as a holistic response to foods, we must first improve our understanding of the term, develop new methods that measure the food experience from different dimensions, and finally study which factors or factors-combinations that are important for the feeling of satisfaction.

The present PhD project took us one step of the way, as it contributed to our understanding of the satisfaction construct, by investigating the term from a theoretical point of view and investigated the factors involved in consumers' feeling of satisfaction.

1.1 Project hypothesis and tasks

Existing research and the overall aim of the SENSWELL project have led to the following hypotheses for the present PhD project:

- Hypothesis 1:** Food satisfaction can be used as a holistic response to consumers' hedonic appreciation of foods
- Hypothesis 2:** Satisfaction with foods is multidimensional and the sensory experience as well as other product related factors, person- and situational factors contribute to satisfaction

These hypotheses were investigated by the following sub-aims:

Connected to hypothesis 1:

- to establish a theoretical understanding of the satisfaction term
- to develop a working definition of satisfaction to be used prospectively in the PhD project

Connected to hypothesis 2:

- to develop a vocabulary of factors potentially affecting satisfaction
- to develop a method measuring satisfaction and use it to measure satisfaction in case studies
- to explore the influence of product-, person- and context related factors in satisfaction in concrete product cases

1.2 The PhD projects five phases

To investigate the hypothesis and sub-aims an explorative approach was employed. Figure 1 gives an overview of the PhD projects four phases, inclusive the overall purpose of the respective phase and outcomes. Following is a short description of the five phases.

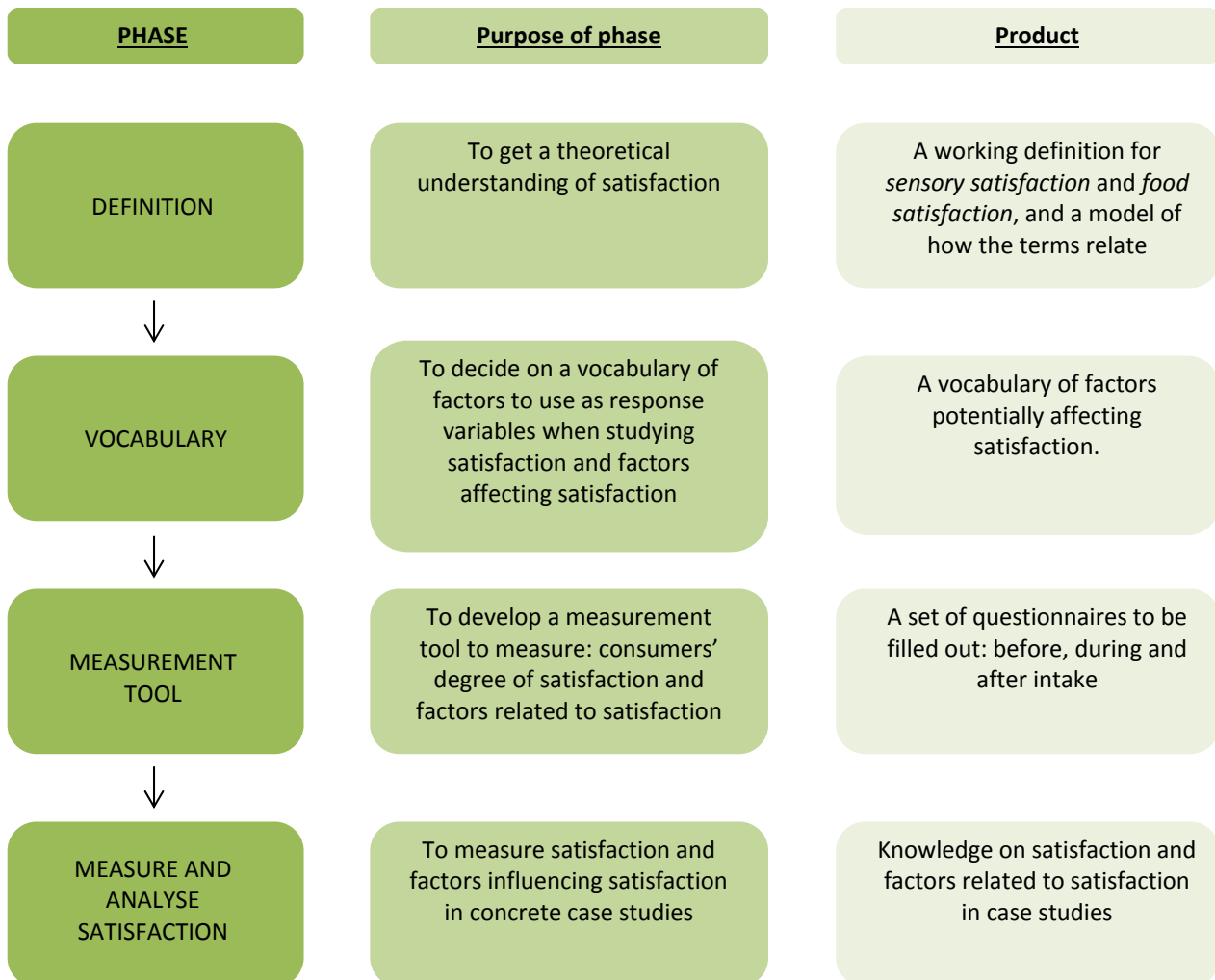


Figure 1. Phases in the PhD, inclusive purpose with- and outcome of the respective phases.

The *first phase* within the PhD project covered a theoretical understanding the satisfaction response, emphasising an understanding of: the type of response, the focus of the response and the timing of the response. The work on understanding satisfaction resulted in a division of satisfaction into two satisfaction terms: sensory satisfaction (SS) and food satisfaction (FS). The outcome was a working definition of SS and FS and a model illustrating how the two terms were related.

The *second phase* concerned development of overviews of factors potentially affecting satisfaction (regardless of focus on sensory satisfaction and food satisfaction). Existing literature was reviewed and as satisfaction was not used as a response variable in most studies within sensory science, factors affecting hedonic food appreciation, acceptance and well-being in general were included in the overview as well. The result was a list of factors potentially affecting food satisfaction. The list

of factors used as response variables in the method measuring satisfaction is referred to a “vocabulary”, and can be seen from appendix 1 (the response variables included in the respective questionnaires).

The *third phase* concerned development of a measurement tool to measure SS and FS and factors affecting SS and FS. Based on the finding that a broad range of factors potential could affect satisfaction, and the desire to study several of these factors simultaneous, a questionnaire method was chosen. A set of questionnaires were developed to be handed out to consumers before-, during- and after intake. The questionnaires can be regarded a standard set of questionnaires with application to a broad range of foods (including beverages). A pre-test was conducted with the purpose of detecting if any questions were misinterpreted or difficult to answer.

In the *fourth phase* the questionnaires were put to use in three case studies; a soup-, a yoghurt w/muesli- and a fruit drink case study. Short descriptions of the respective studies and papers written in relation to the respective studies are presented in section 1.4. For more detailed descriptions of studies please confer the papers in appendix 3. The basic set of questionnaires were used in the soup study, a slightly modified version incorporating variables one hour after intake was used in the yoghurt w/muesli study and a more product specific version was used in the fruit drink study. The different versions of questionnaires can be seen in appendix 1. Common for all questionnaires were the study of SS and FS and related factors.

1.3 Chapters in the thesis

The overall purpose of this thesis is to describe how satisfaction term is understood, the development of the questionnaires and discuss the obtained results regarded factors affecting sensory satisfaction and food satisfaction in relation to established research. As “satisfaction” is not used as response variables in the majority of studies conducted within sensory science, results will also be compared to research applying a variety of hedonic response variables and intake. In accordance the following chapters are included in the thesis:

Chapter 1 introduces the PhD project and the thesis. Further, the chapter provides an overview of four different working-phases within the PhD project, and an overview of the studies and papers conducted in relation to the PhD. *Chapter 2* deals with the understanding of satisfaction. Previous definitions of satisfaction (used within sensory science) are analysed, and a working-definition of FS is presented. In this chapter a definition of SS are presented in addition to the definition of FS, and throughout the PhD, SS is the one dimension in FS which receives the most attention. The definitions of FS and SS illustrate, how the terms have been understood and used throughout the PhD project. *Chapter 3* describes the development of a vocabulary of factors potentially affecting FS, when focus was on finding potential determinants to satisfaction across a broad range of products. Considerations regarding a temporal perspective when measuring FS are presented. Further, the differences between the different questionnaires used in the respective studies are described. *Chapter 4* describes how FS have been measured and analysed, along with considerations on the development of questionnaire. *Chapter 5* discusses findings from studies conducted in relation to the PhD project, with focus on factors influential in FS. Selected “product

related-”, “product-person inter-related -”, “person related-” and “context related factors” are discussed in detail. *Chapter 6* compares the measure of “SS” to the measure of “overall liking” and discusses differences. Finally conclusions and perspectives on the works conducted are given in *chapter 7* and *8*.

1.4 Overview of studies and papers

Figure 2 provides an overview of studies conducted and papers written in relation to the present PhD project. The figure is followed by short descriptions of the respective studies and papers. Further details can be found in the respective papers in appendix 3.

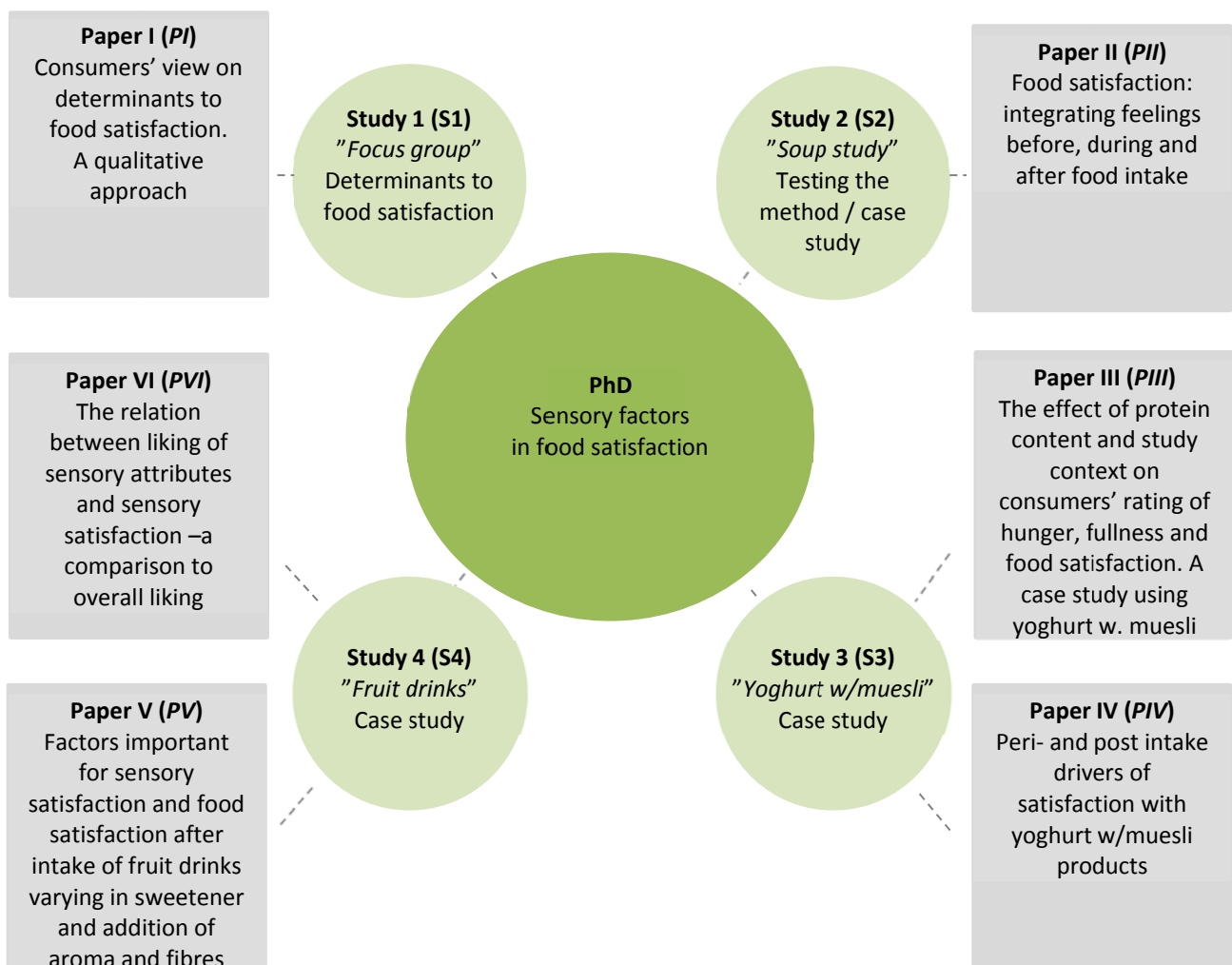


Figure 2. Overview of studies conducted and papers written in relation to the PhD project

Study 1

The first study (*S1*) approached FS qualitatively by investigating determinants to FS from consumers' perspective through focus group interviews. This study formed the basis of paper 1 (*PI*).

PI: Consumer views on determinants to food satisfaction. A qualitative approach.

Introduction: "Satisfaction" has been suggested by Cardello et al (2000) as an alternative measure to overall liking, when measuring consumers' appreciation of foods. In contrast to overall liking which is believed to reflect the hedonic sensory experience, "satisfaction" is believed to imply a generalised appreciation of the food within its context. In future quantitative studies, "satisfaction" will be used as holistic response variable to measure consumers' food appreciation, and determinants to satisfaction will likewise be studied. To increase likelihood that consumers can relate to the response variables in the questionnaire, determinants to satisfaction was studied from consumers' perspective.

Aim: This study aimed to gain an understanding of the multiple determinants to satisfaction from a consumer perspective.

Method: 20 consumers participated in semi structured focus group interviews. The focus groups were organised around themes and tasks to ease the dialogue about FS.

Results: Factors important for the feeling of satisfaction appeared before-, during- as well as after intake. Before intake, memories about previous eaten foods formed the basis of expectations and desires to the forthcoming meal. During intake, the sensory experience was mentioned as the primary determinant to satisfaction. Post intake, physical wellbeing including a feeling of appropriate energy level and satiation were mentioned determinants to satisfaction. In addition, consumers argued that satisfaction could be enhanced by the social eating context and knowledge about the food e.g. origin and health value.

Conclusion: Results will be used in the development of questionnaires measuring factors of importance for FS

Study 2

In the second study (*S2*) the questionnaires covering factors of importance for FS was put into use in a case study on two sensory different variants of a creamy chicken soup. The main objective was to test if the questionnaires could give detailed information about sensory- and food satisfaction. Further, the objectives were to study factors before-, during- and immediately after intake of importance for SS and FS. This study formed the basis of paper 2 (*PII*).

PII: A new method studying sensory- and food satisfaction provide detailed information on the factors related to satisfaction

Introduction: Determinants to FS are multifactorial and a method approaching the multiple determinants is believed to provide detailed information about the primary drivers of FS.

Aim: The aims of this study were to 1) to develop a method that could give detailed information about sensory- and food satisfaction 2) to study differences in sensory satisfaction in a case study 3) to study the factors influencing food satisfaction.

Method: 79 consumers participated in a cross-over study on two sensory different variants of a creamy chicken soup; A) a plain soup and B) a soup with pieces of chicken, vegetables, parsley and croutons. A total of four questionnaires covering factors of importance to satisfaction before-, during- and after intake, and demographics were filled out by consumers. Further, soups were sensory evaluated utilising expert statements.

Results: The study showed that SS was highly influenced by liking of taste and appearance. Liking of odour and texture influenced SS moderately. Food satisfaction was influenced by factors measured during- and post intake; SS, fulfilment of expectations, reason for ending intake, product performance relative to expectations, hunger and fullness after intake were found highly influential in FS.

Conclusion: The use of multiple variables gave a detailed picture of factors involved in food satisfaction, but there was still variation in FS that remained unaccounted.

Study 3

In the third study (*S3*) drivers of SS and FS were studied in a case study on yoghurt w/muesli products. As the yoghurts differed in protein-/total energy content, the study of between-product differences in satiation, satiety and FS was emphasised. Two variants of muesli were used, and factors before-, during-, after- and one hour after intake of importance for SS and FS were studied. The effect of data collection context was investigated by conducting the study in a sensory laboratory (*S3a*) as well as in a natural setting context (*S3b*). *S3* further included sensory profiling of yoghurt w/muesli products. *S3a* and *b* formed the basis of paper 3 (*PIII*), and *S3a* formed the basis of paper 4 (*PIV*).

PIII: The effect of protein content and study context on consumers' rating of hunger, fullness and food satisfaction. A case study using yoghurt with muesli products.

Introduction: Protein has been shown an effective dietary strategy to control appetite. Yoghurts are popular products consumed for breakfast and as snacks. This makes yoghurts w/muesli relevant products to use when studying the effect of increased protein content of satiation, satiety and FS. Most studies are conducted in laboratory settings, but the results could be different if the study is conducted in a natural context, therefore the study compared results from the two contexts.

Aim: The aim was to study hunger, fullness and satisfaction in a lab- and a natural context after intake of yoghurt w/ muesli products varying in protein content and muesli variant.

Method: 239 consumers (n_{lab} : 107, $n_{\text{natural-context}}$: 132) consumed and evaluated two of four yoghurt w/ muesli products ad libitum. The design followed an incomplete design with approximately the same number of consumers evaluating each product. Before intake measures included: hunger and fullness, immediate after intake measures included: hunger, fullness and satisfaction, and one hour after intake measures included: hunger and satisfaction.

Results: Products, regardless of protein content, muesli variant and study context led to reduced hunger and increased fullness. No difference in hunger was found between products. Fullness was significantly higher for the high-protein products compared to the normal-protein products, but only in the lab study. A muesli effect was found on satisfaction, with the nut variants receiving highest satisfaction ratings regardless of protein content. This effect was only apparent in the lab study. A

main study-context effect was found on immediate post intake hunger, fullness and satisfaction ratings.

Conclusion: As the results did not only reflect differences in protein content but also in energy intake and sensory perceptions interpretation of the effect of protein content on hunger, fullness and FS was difficult.

PIV: Pre- and post intake drivers of satisfaction with yoghurt with muesli products

Introduction: FS is believed to be affected by sensory characteristics as well as sensations related to the post ingestive- and post absorptive processes following food consumption (Boelsma, Brink, Stafleu, & Hendriks, 2010). However it is unknown which variables that mainly drive FS.

Aim: The aim of this study was to determine the variables mainly influencing satisfaction immediately after intake and one hour post intake

Method: 107 consumers consumed and evaluated two of four yoghurt w/muesli products consisting of two variants of yoghurt and two variants of muesli. Evaluation included questions related to SS, physical- and psychological wellbeing sensations and FS.

Results: Variables highly influential for food satisfaction immediately after intake included: sensory satisfaction, product performance relative to expectations, reason for ending intake and general liking of yoghurt w/muesli products. Variables highly influential for food satisfaction one hour after intake included: memory of sensory satisfaction, experiencing pleasant energy level and stomach feelings, BMI status, consumption frequency and general liking of yoghurt w/muesli products. As SS was found a main driver of FS, sensory differences between products were studied through sensory profiling and related to consumers rating of SS. Analysis of sensory- and consumer data showed that muesli differences dominated differences in sensory perceptions and consumer hedonic scores.

Conclusion: Sensory properties had a prominent role in food satisfaction, but physical well-being related sensations and demographics contributed to FS as well.

Study 4

The last study conducted in relation to this thesis was a case study on apple-cherry fruit drinks (*S4*). The overall aim of *S4* was to study consumers' hedonic sensory experience and post intake sensations following intake of four apple-cherry fruit drinks differing in: used sweetener, and fibre- and lime-aroma content. Factors before-, during- and immediately, 10, 20, 30 and 40 minutes after intake were studied.

Taste samples of 25 ml and full size bottles of 250 ml, were used in the study. Prospectively in this thesis, the part of the study focusing on consumers evaluation of taste samples will be referred to as study 4a (*S4a*) and the part of the study focusing on consumers evaluation of bottles will be referred to as study 4b (*S4b*). *S4a* formed the basis of paper 6 (*PVI*) whereas *S4b* formed the basis of paper 5 (*PV*).

PV. Factors important for sensory satisfaction and food satisfaction after intake of fruit drinks varying in sweetener and addition of aroma and fibres

Introduction: Strategies to reduce energy intake include replacement of energy dense ingredients with low-energy alternatives and adding ingredients to increase satiation and satiety. In this study, consequences of replacing sucrose with Stevia and adding fibres and lime aroma on sensory products profile, perceived physical sensations and hedonic ratings are studied.

Aim: the aims was to study a) sensory and hedonic differences in perception of products differing in use of sweetener and addition of lime aroma and fibres b) to study whether the product differences led to differences in the physical sensations immediately up until 40 minutes after intake, and c) to study the main drivers of satisfaction.

Method: Four apple-cherry fruit drinks varying in: type of sweetener used and if fibre and lime aroma had been added were sensory profiled and rated by 66 consumers. In the consumer study, physical sensations and hedonic product perception were rated before and immediately after intake as well as at time 10, 20, 30 and 40 minutes after intake

Results: 12 sensory attributes were found to significantly describe product differences. No differences in sensory perceptions, hedonic ratings and physical sensations were found between two products differing in whether sucrose or stevia had been used as sweetener. These two products were preferred by consumers compared to products containing fibres and lime aroma. Adding fibres resulted in significantly lower drinkability and satisfaction (SS and FS), and higher ratings of fullness and if the fruit drinks could replace a snack immediately after intake. At time 10 minutes after intake, nausea and if the fruit drink could replace a snack were rated higher for the fruit drink containing fibres. No difference between products was found at time 20-40 minutes after intake. Variables mainly influencing FS was: SS, drinkability, snack replacer, psychological wellbeing, energy, fullness, age group and nausea.

PVI: The relation between liking of sensory attributes and sensory satisfaction -a comparison to overall liking

Introduction: In the SENSWELL project SS is used as an alternative to liking. In the measure of SS consumers' are guided to consider liking of appearance, odour, taste and texture, but are all four properties considered equal? and does the relative importance of liking of each property differ between measuring SS or the common measure of overall liking? These questions are studied in the present paper.

Aims: The main aims of this study were a) to study if the relation between liking of sensory properties and SS differed from the relation between liking of sensory properties and overall liking? b) to study if liking of each sensory property differed in their relation to SS and overall liking? and, c) to study individual differences

Method: 67 consumers tasted and evaluated four fruit drinks differing in: used sweetener, added fibre- and lime aroma content. Evaluation questions included: overall liking, liking of: appearance, odour, taste and texture respectively and SS.

Results: The study showed no differences in the relation between liking of sensory properties and SS and liking of sensory properties and overall liking. Results showed that liking of sensory properties differed in relation to overall liking and sensory satisfaction, respectively. Consumers primarily paid attention to liking of taste, when evaluating overall liking and sensory satisfaction, respectively. However, individual differences were found.

CHAPTER 2: UNDERSTANDING THE SATISFACTION TERMS; SENSORY SATISFACTION AND FOOD SATISFACTION

2.1 How has satisfaction been understood and defined previously?

The term satisfaction is a relatively new term within sensory science and has not been used widely. Research has to a large extent focused on “acceptance” and “preference”, but never the less is it widely accepted that intake of food can bring a feeling of satisfaction and affect the behavioural decision of deciding what to eat. In the recent years, satisfaction has received increasing attention in sensory science, but the exact definition is lacking. Below are three working definitions that reflect how satisfaction has been understood in specific studies conducted within sensory science. Note that the second definition defines postprandial wellness, but Boelsma and colleagues (2010) found it closely related to satisfaction. Further, the definition by Mojet (2011) was presented at a SENSWELL kick-off meeting for which reason no written material can be found. The definition is presented with permission from Jos Mojet.

Satisfaction implies a generalized appreciation of the food within some broader situational context. It may imply something about the food's value, its utility, or its adequacy for the situation (A. V Cardello, Schutz, Snow, & Leshner, 2000)

Postprandial wellness, the subjective appreciation of food after intake: the degree to which physiological and psychological sensations resulting from the food intake process match with our preferences and are enjoyed (Boelsma et al., 2010)

Food satisfaction is the feeling of a more than averagely pleasant state which is explicitly or implicitly attributed to the (previous) consumption of food in a given eating situation (Mojet, J., 2011)

Satisfaction has been assigned much more focus within the area of marketing (e.g. Oliver, 2010). Despite the extensive research, researchers have yet to develop a consensual definition. Giese and Cote conducted a literature review and found 20 definitions used during a 30-year period. For an overview of the definitions see the paper by Giese and Cote (Giese & Cote, 2000). The same authors conducted group interviews and personal interviews to develop and discuss a framework for a definition of satisfaction. The aim was to ensure that the framework was consistent with consumers' meanings of satisfaction. Based on the literature review and the interviews, Giese and Cote found that though the literature contained differences in the definition of satisfaction, all the definitions shared some common elements. Three general elements could be identified: 1) consumer satisfaction as a response; 2) the response pertained to a particular focus; and 3) the response occurred at a particular time.

Satisfaction as a response: Giese and Cote (2000) found that most definitions regarded satisfaction a response to an evaluative process, and especially a summary outcome where several experiences contributed to the final response (i.e. a fulfilment response (Oliver, 2010)). However, little agreement has been found on the nature of the summary concept. Most researchers either conceptualized satisfaction as an emotional response or cognitive response. The interviews by Giese

and Cote showed that consumers primarily used affective responses to describe satisfaction, i.e. “I am happy”, “I like it”. These responses are typical emotional descriptors (Richins, 1997). The three definitions presented above support the results found by Giese and Cote, as hedonic terms are used to describe the satisfaction response; appreciation and pleasant state. Results from S1 likewise support the results by Giese and Cote, as participants used affective responses to describe satisfaction i.e. “I appreciate”, “I feel better”, “I feel happy”. The intensity of the response (the strength of the satisfaction response) vary between definitions, which can also be seen in the three definitions written above. In Mojet’s definition the feeling should be “more than averagely pleasant” whereas the intensity is closer to neutral, yet still positive, in the definition by Cardello and colleagues’ and Boelsma and colleagues’; “generalized appreciation” and “match with preferences and are enjoyed”. Giese and Cote likewise found varying intensity in the satisfaction response.

Focus of the response: The focus identifies the object of consumers’ satisfaction, and can vary from context to context. Common foci include: expectations, product and consumption experience (Giese & Cote, 2000). In the definitions written above, focus is in all cases on the food-item, but what the food is related to, varies. In Cardello and colleagues’ definition, food performance is rated associated to the situational context. In Boelsma and colleagues’ definition, the food is rated associated to physical- and psychological sensations experienced relative to expectations. And in Mojet’s definition, the food is associated to the eating experience inclusive the context in which it was/is eaten. In S1 the participants talked about different foci; fulfilment of expectations and desires, sensory food properties, physical wellbeing (energy level and satiation), the food context, food origin and health value. This indicates that consumers can talk about satisfaction while having only one of these foci in mind or refer to several foci and thereby consider satisfaction a summary outcome. Note that consumers might not be as consciously aware of the exact focus, as it is put here.

Timing of the response: Satisfaction can be determined at various points in time. Within marketing consumer satisfaction has often been measured prior to- or after choice, or after consumption (Giese & Cote, 2000). In Cardello and colleagues’ definition (2000), satisfaction is evaluated after perceiving the food in its context, though not defined directly. For example, the timing relative to intake is not specified. In Boelsma and colleagues’ (2010) and Mojet’s (2011) definition, satisfaction/wellness is evaluated after consumption. Mojet further imply that satisfaction can be determined a longer timespan from intake e.g. measured through memory. Giese and Cote (2000) found that consumers determined satisfaction before consumption (39,9%), during consumption (48.2%) or after consumption (11.9%). Though the percentages are results from a qualitative study and can therefore not be generalised, they can bring an indication of when satisfaction previously has been determined. Note that the study is conducted within marketing research where the purchase situation and extrinsic product characteristics also was studied. These factors are not in focus within sensory science. Therefore, the numbers could very well be different if a quantitative study was conducted, and/or if the study was conducted within sensory science research.

2.2 How to understand sensory- and food satisfaction in relation to present PhD project?

The three elements found by Giese and Cote (2000); response, focus and timing, were used to develop two definitions to be used within the present thesis and the studies conducted in relation to the PhD project; a definition of *sensory satisfaction* and a definition of *food satisfaction*. A definition specifically on sensory satisfaction was desired, as there was increased focus at sensory properties in the PhD.

Sensory satisfaction:

*A positive evaluative response to food,
evoked by the foods appearance, odour, taste and texture*

Food satisfaction:

*A positive evaluative response to food in its context,
after perceiving it and physical- and psychological sensations
resulting from the consumption process*

In both definitions satisfaction is regarded a summary affective outcome of an evaluative process, but the focus and timing differ.

In *sensory satisfaction*, the food is evaluated based on a summary of how the foods sensory properties perform. The experience of the sensory properties is evaluated against an internal standard of how appearance, odour, taste and texture should and/or are desired to perform. The consumer is believed to consider the appearance, odour, taste and texture, but the importance of each property might not necessarily be equal in the final satisfaction outcome. As introspection is difficult and other experiences are believed easily to affect the outcome of sensory satisfaction, the response should preferably be measured while the sensory properties are perceived. Therefore, in the studies conducted in relation to the PhD, sensory satisfaction was measured during intake. An exception is S4b where SS was measured immediately after food intake, due to methodological reasons.

In *food satisfaction*, food performance is evaluated based on a summary of how the food performed in its context. Included in the evaluation are physical- and psychological sensations resulting from the consumption process i.e. sensory experiences, satiation and mood. The perceptions are evaluated against an internal standard of how the food product should and/or are desired to perform in the given context. As foods can create physical- and psychological sensations both immediately after intake and a longer time from intake, food satisfaction can be measured at various time points after intake. In the studies conducted in relation to the PhD, food satisfaction was measured immediately after intake (S2, S3a, S3b and S4b), at time 10, 20, 30 and 40 minutes post intake (S4b) and one hour post intake (S3a and S3b).

The two definitions do not indicate certain intensity of the response (beside that the response is positive). Therefore, the satisfaction definitions acknowledge that the intensity of the response can vary from slightly above neutral to extremely positive and still be regarded satisfaction.

In both definitions, an internal standard forms the basis for comparison. Internal standards refer to expectations and desires, created by previous experiences and memories about the previous

experiences. Consumers are assumed to be satisfied when the expectations and desires are met, and when unexpected additional pleasure is experienced (Deliza & Macfie, 1996). If unexpected less pleasure is experienced, consumers are believed primarily to be dissatisfied but in given situations satisfaction can occur. An example is, if very high expectations are unfulfilled but yet leave the consumer with a positive experience (Oliver, 2010).

Figure 3 illustrates how SS and FS are considered to be related, how the terms relate to other foci and future food experiences. The relation between SS and FS is highlighted.

The pathway leading to sensory satisfaction can be regarded as followed: The sensory properties are perceived by the consumer. The perceptions are compared to expectations and desires about the experience (internal standard), and the result is a summary outcome of how the food performed. Note, the outcome is not always positive like in the case of satisfaction. Dissatisfaction or a neutral state is also possible. However, for the sake of simplicity satisfaction will only be mentioned. SS is affected by our memory of past experiences, as these create expectations and desires for the perception. The expectations and desires do (in themselves) also affect how we perceive the sensory characteristics.

FS is influenced by SS as well as satisfaction with other foci. Other foci could for example be: the social eating context, physical sensations and psychological well-being after intake. As illustrated in the bottom of the figure, satisfaction judgments can be regarded outcomes of a process that never ends. What can be considered satisfaction with a present food product, will be considered a “previous experience/memory” when the next experience is being evaluated. Basically, expanding our “list” of experiences will affect future expectations.

Surrounding the satisfaction process is the specific context in which the food is eaten. The context implies a broad range of circumstances, inclusive personal circumstances: physiological- and psychological state, beliefs and values etc. and surroundings like: occasion, location, and social company etc. How the food is perceived, is likely to be affected by the specific context in which the food is eaten and the subject experiencing it.

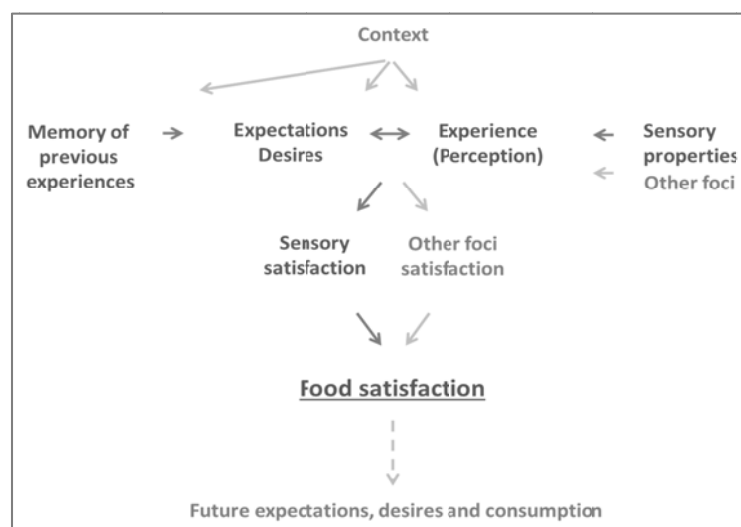


Figure 3. The relation between sensory- and food satisfaction, and their relation to other foci.

CHAPTER 3: DEVELOPMENT OF A VOCABULARY OF FACTORS POTENTIALLY AFFECTING FOOD SATISFACTION

Determining which factors to focus on when studying factors influential in FS is not straightforward. The potential factors are numerous, complex and do often interact. Further, the factors vary among individuals, but also within the same individual in different contexts and periods of time (Costell, Tárrega, & Bayarri, 2010). FS is basically the result of an interaction between food and man in a certain moment. Product related factors, person related factors and factors in the consumers' environment influence consumers' attitude towards a food product and the degree of pleasure when consuming it (John S.A. Edwards, Hartwell, & Brown, 2013; H. L. Meiselman, Johnson, Reeve, & Crouch, 2000). Many factors derive from intrinsic properties of the food, which primarily operate through human sensory and perceptual systems. During food consumption the brain receives different sensory input, and information from physiologically distinct sensory modes integrates into the final sensory perception. For consumers, each perceived sensation do not only reflect a certain sensory input but also other inputs perceived simultaneously and interactions among them. The degree of pleasure can e.g. be influenced by a consumers' attitude and opinion about nutritional value, safety, price and labelling of the product. These factors primarily operate through cognitive and psychological mechanisms, often through expectations generated by the consumer (Deliza & Macfie, 1996). Other aspects include a consumers physical state, genetics and perception ability (A. Drewnowski, 1997). Further, other aspects include psychological factors e.g. changes in mood, previous experiences and contextual factors.

In this section considerations will be presented regarding how the response variables in the respective questionnaires were selected. The section will first present a model which was developed to gain an overview of factors which could influence FS. Next, considerations regarding the timing of the satisfaction measure will be presented, and finally, differences between the respective questionnaires will be described.

3.1 Overview of factors potentially affecting food satisfaction

Prior to deciding on a vocabulary of response variables which should be rated by consumers in the respective studies, a model of factors influential in FS were developed (Figure 4). In the model, factors are classified into "product related", "person related", "product-person inter-related" and "context related" factors. However, as the factors are linked to each other and affect each other, they can be argued to belong to several classifications depending on how you interpret the factor. Keeping this in mind, the model can be regarded a rough classification of the factors affecting food satisfaction.

The model is inspired by Mojet's model of factors influencing food choice and behaviour (E. P. Köster, 2009), which can be found in appendix 2. Though the main focus in the two models are two different constructs (food choice vs. FS), many of the specific factors included in Mojet's model are believed to affect FS as well. A marked difference in the two models is the inclusion of the category "product-person interrelated factors" in Figure 4. As FS is measured after consumption, many of the factors affecting FS cannot be classified as either "product-" or the "person related", but are an integration of how the product is perceived by the individual subject. An example is physical well-

being. If physical well-being is measured before intake, it can be regarded a factor belonging to the category “person related factors”. However, when physical well-being is evaluated after intake, physical well-being is believed both to depend on the product consumed, and the individual perceiving product-induced consequences. Therefor physical well-being will be categorised as a “product-person inter-related factor”. That “product-” and “person-” related factors can represent individual classification or be combined into the classification “product-person inter-related factors”, depending on when satisfaction is measured are indicated by the “dashed lines” in Figure 4.

Besides being inspired by Mojet’s model of factors affecting food choice and behaviour, the model is created based on results from S1. In the focus group interviews (*PI*), four main groups of factors were mentioned to affect FS: 1) sensory properties, 2) physical well-being, 3) expectations and desires and 4) the food context. Each of these factors can be argued to belong to different classifications; sensory properties to the product related factors, physical well-being (post intake) to the product-person inter-related factors, desires and expectations to the person related factors, and the food context to the context related factors. The model contributed to the PhD project by providing an overview of potential response variables to measure, when studying determinants to FS, and was used to decide on a method for measuring FS.

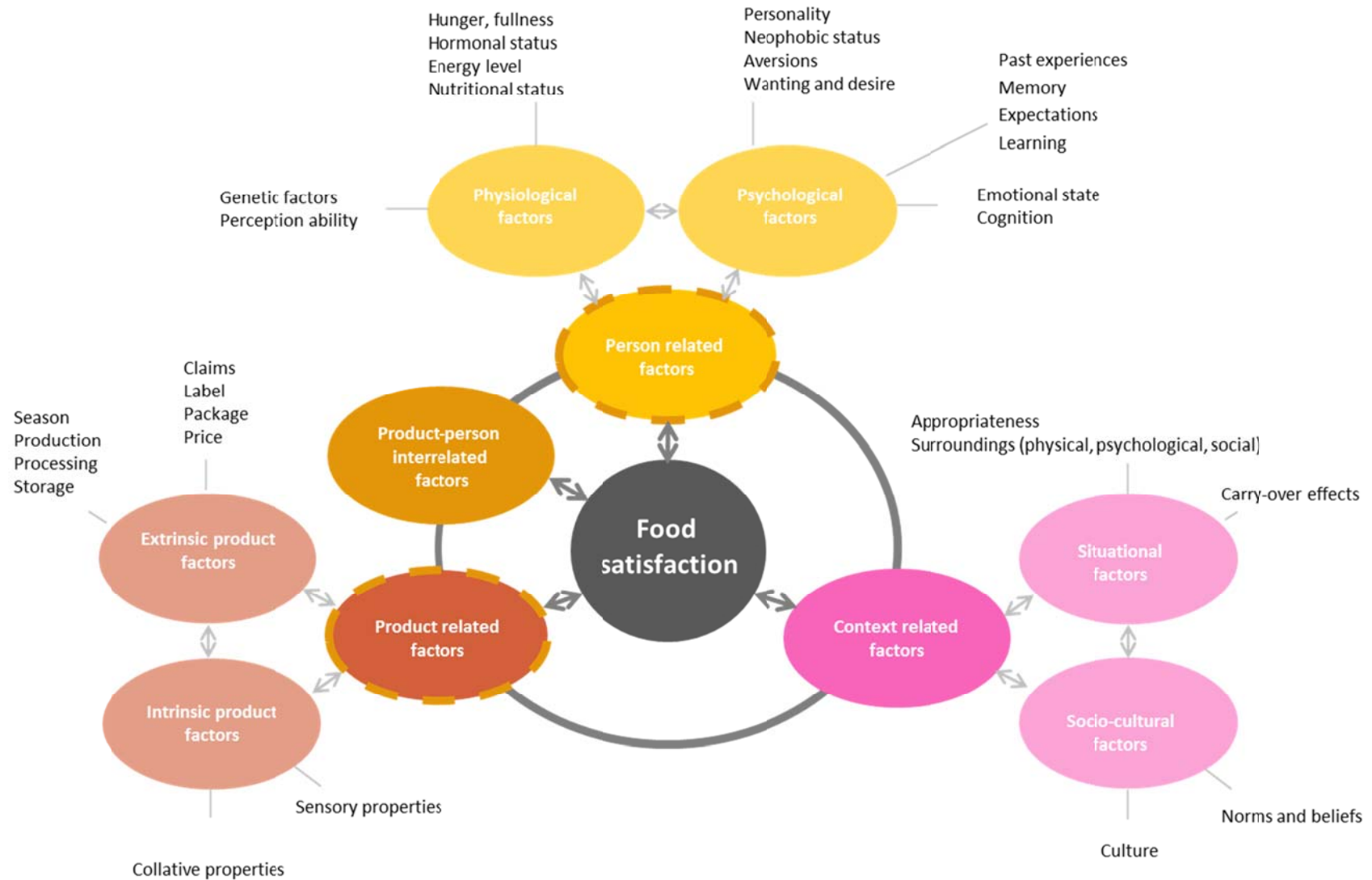


Figure 4. Factors influential in food satisfaction. Dashed lines around the classifications: “product related factors” and “person related factors” indicate that the single factors within these classifications can be regarded as “product-person inter-related” if food satisfaction is measured after intake. The specific factors are meant as examples not as a complete list.

3.2 Temporal perspective

As found in S1 and illustrated by Giese and Cote (2000), satisfaction can be measured at various time points in relation to intake. In the present PhD project four temporal points of measuring satisfaction were considered: *before intake*, *during intake*, *immediately after intake* and selected time points *a longer timespan after intake*. Depending on when FS is measured, different processes are believed primary to influence FS: Cognitive, sensory, post-ingestive and post-absorptive (Figure 5).

If measuring satisfaction *before intake*, cognitive effects are believed primarily to influence the satisfaction response. Cognitive effects relate to expectations and desires about the food properties, and their presumed effect on the eater. These expectations and desires are based on learning from previous experiences and memory hereabout.

If measuring FS *during intake*, sensory effects generated through the sight, smell, taste, touch and sound of food are believed primarily to influence FS. This is the process referred to in SS. In addition to the sensory properties themselves, subjective expectations have been found capable to alter the hedonic appreciation of the sensory food properties (see section 5.2.4).

The time point identified as “*immediately after intake*” includes a number of possible sensations which can bring FS. Characteristically for FS measured at this time point is that it is believed primarily to be related to physical- and psychological well-being sensations. Potential sensations for example include: satiation (homeostatic and hedonic), stomach fullness, fulfilment of expectations, food induced mood changes etc. As time from intake increases FS can be measured either in-between eating occasions or through memory of previously eaten foods.

In the time in-between eating occasions, FS is believed primarily to be related to post-ingestive- and absorptive well-being sensations as well as memory about the eating experience. Relevant well-being sensations include: satiety, energy level, pleasant stomach feelings and memory about the sensory experience etc.

If measuring FS at a time point *a longer time span from intake*, satisfaction is primarily believed to be based on memory of the eating experience.

Regardless of when FS is measured, and which processes that primary are related to FS, the feeling of satisfaction will always be generated in a context. The context implies a broad range of circumstances, inclusive personal circumstances: physiological- and psychological state, beliefs and values etc. and surroundings like: occasion, location, and social company etc. How the food is perceived, is likely to be affected by the specific context in which the food is eaten.

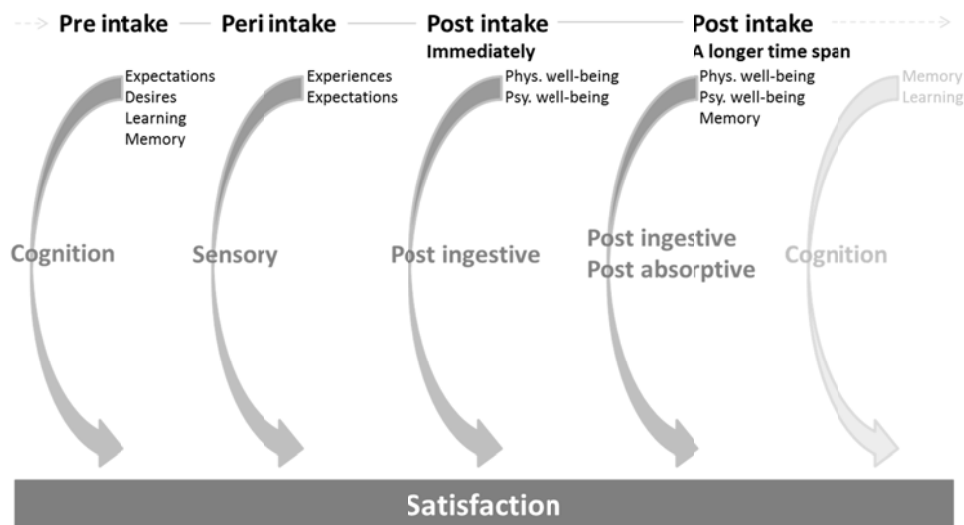


Figure 5. A temporal perspective on the processes believed to affect satisfaction

3.3 Differences between questionnaires applied in the present PhD project

Based on the interpretation that a broad range of factors potentially could affect satisfaction, and the desire to study several of these factors simultaneous, a questionnaire method was chosen. The vocabulary of response variables included in the respective questionnaires can be found in appendix 1.

The questionnaires used in S2 can be considered the basic set of questionnaires from which the questionnaires used in the following studies were developed. The questionnaire used in S2 measured “SS” during intake and “FS” immediately after intake, and variables that were believed to influence SS and FS were measured before-, during- and immediately after intake. Before intake, consumers’ expectations about the food, strength of expectations, wanting, subjective physiological- and psychological states as well as appropriateness was measured. During intake, consumers’ appreciation of sensory properties was measured. After intake, reason for ending intake, FS, fulfilment of expectations, hunger, stomach fullness, desire for other foods, physiological- and psychological states and desire to eat again were measured. The questionnaire after intake further included questions related to demographics and general- food behaviour and attitude.

Minor modifications were done regarding the variables included and scales applied in the questionnaire used in S3 and S4 compared to S2. Modifications were done with the purpose of increasing user friendliness and ease analysis- and interpretation of results.

Beside the modification, a measure of “memory about SS” and “FS” were added one hour after intake in S3, as well as variables believed possible to influence “memory of SS” and “FS” one hour after intake. The questionnaire used in S3b also included questions about the consumption context, as this study was conducted in a natural context opposite S2, S3a and S4 which were conducted in a sensory laboratory. The questionnaires used in S2 and S3 were developed so that they could be applied to a broad range of products. The questionnaires used in S4b differed, as the variables were chosen specifically for the products being studied. Of methodological reasons, a different timeframe was used in this study.

CHAPTER 4: MEASURING AND ANALYSING FOOD SATISFACTION

4.1 Measuring food satisfaction using focus groups

In S1 food satisfaction was approached from a qualitative perspective. The qualitative methods are especially useful for: 1) exploration and discovery 2) context and depth, and 3) interpretation (Morgan, D. L. 1998). One way to summarise qualitative methods is that they bring an understanding of why things are the way they are, and how they got to be that way. These characteristics are shared by all qualitative methods (Morgan, D. L. & Krueger, R. A. 1998). New topics, like determinants to sensory- and food satisfaction, can therefore by advantage be explored qualitatively.

Among the qualitative methods, focus groups were chosen, as they encourage interaction among participants (Casey, M.A. & Krueger, R.A. 1994). Determinants to satisfaction, for example sensory characteristics, are generally considered difficult for consumers to word and describe. By using focus groups, participants could be inspired by each other's use of words, and thereby ease a dialogue which could otherwise have been difficult. On this point the focus group offers an advantage compared to in-depth interviews.

Focus groups are often questioned about validity, reliability and generalizability. Compared to quantitative research focus groups do not have random sampling, researcher distance and procedures for statistical analysis. However regardless of type of research, validity and reliability are concerns that can be approached through attention to how data were collected, analysed and interpreted. Techniques applied in the focus groups to ensure validity included:

- Spending sufficient time during data collection to follow the prepared questioning route as well as deviations
- Using multiple researchers; an assistant moderator during the data collection phase and a second researcher during the data analysis phase to expand and clarify thinking on findings and interpretations
- Using multiple methods; video monitoring to study verbal as well as non-verbal information, and notes from assistant moderator

Qualitative methods can be appropriate in a lot of cases. Within sensory science they have been used within: new product development (e.g. Raz et al., 2008), identification of sensory attributes that strongly influence consumer acceptance (Lawless & Heymann, 2010), pre-screening of questionnaires (*PII*), follow-up after consumer tests and exploration of beliefs and attitudes towards specific foods, ingredients, production methods and nutritional issues (e.g. Smith et al., 2006), and perceptions (e.g. Murray & Vickers, 2009) and attributes (Buck, D. 2007). In S1 (*PI*) focus groups were used to explore how satisfaction was felt by consumers and which factors consumers were consciously aware of affected food satisfaction. A detailed description of the procedure can be found in *PI*.

4.2 Analysis of focus group interviews

Several methods can be applied to analyse data from focus group interviews (Casey, M.A. & Krueger, R.A.). The choice of method is related to the importance of the decision to be made based on the findings and the amount of resources available. Some of the most common approaches include: analysis of transcripts of whole interviews, analysis from abbreviated transcripts, analysis from audio-tapes and analysis from summaries. A more elaborate analysis procedure involves coded transcripts which can check for inter-rater reliability. However, the latter method provides more detail than is required by most studies interviews (Casey, M.A. & Krueger, R.A.). Further, software programs are available to assist the analysis. In S1, summaries were conducted from audio- and video recordings and notes taken by a moderator assistant. Summaries were made by two researchers independently to obtain a coherent picture of what had been discussed in each group. The summaries made a foundation for a thematic analysis where consumers' responses were grouped based on similarities and differences. Quotes were transcribed to illustrate the themes.

4.3 Measuring food satisfaction using questionnaires

In S2, S3 and S4 SS and FS were approached from a quantitative perspective. Questionnaires served to quantify consumers' degree of SS and FS, and determine influential factors. As the process of designing the questionnaires was comprehensive, selected details are described below.

Flow

In the design of questionnaires considerations were made regarding the flow, emphasising questions to develop from general to more specific e.g. asking about overall liking before liking of sensory properties. This is a basic recommended principle (Lawless & Haymann, 2010; Resurreccion, 1998). However, this principle was occasionally compromised due to the sake of user-friendliness. For instance rating SS (“*if you consider the odour, appearance, taste and texture altogether, how satisfied are you then?*”) can be regarded a rather general measure, for which reason, the question are considered to be asked in the beginning of the questionnaire. However, the question was placed after asking about liking of each of the sensory properties (generally considered more specific questions), as the question about sensory satisfaction then was thought easier to answer. Further, considerations were made regarding the order of questions, emphasising questions to be asked in the order that seemed naturally e.g. like of sensory properties followed the order; appearance, odour, taste and finally texture. In general, questions about individual attributes may cause respondent to become unrealistically analytical (Lawless & Haymann, 2010). This risk cannot be completely avoided. However, by keeping the questions on an overall level the risk is though minimised. Open-ended comment field in the end of each questionnaire allowed consumers to add additional comments, and hereby, the risks of consumers transferring perceptions, which were not addressed, to other questions were minimised.

Types of scales used

In the studies conducted in relation to the PhD, a 9-point hedonic scale was the primary scale applied (though satisfaction was measured instead of liking). The 9-point hedonic scale is a bi-polar scale with four positive and four negative categories balanced around a neutral category in the centre. Categories are labelled with phrases representing various degrees of affect, suggesting a

continuum of likes and dislikes. The 9-point hedonic scale are the most commonly used rating scale for assessing liking and disliking (Lim, 2011), and has been used in various food, beverage and non-food studies, since it was first introduced by Peryam and Giardot (Peryam & Giardot, 1952). The primary reasons for its popularity include that it is easy to use and implement, and it is as sensitive to product differences as other scaling techniques (Lawless & Heymann, 2010). On the negative side, the 9-point hedonic scale have been criticised for categories not being quite equally psychologically spaced (Jones, 1954; Moskowitz, 1971). This is a problem, as the variance in rating can indicate different ways of understanding the scale instead of different levels of preference. However, despite this problem Peryam and Pilgrim found, that treating the data as the categories were equally spaced gave similar results as treating the data as if it was not (Peryam & Pilgrim, 1957). One advantage of treating categories equally spaced, is that responses, in practice, can be treated as point on a continuum allowing the user to apply parametric statistics such as analysis of variance which are more sensitive than non-parametric tests (Lim, 2011). In the studies conducted in relation to the PhD project two versions of the 9-point hedonic scale was used; one with labels on all 9 categories (S2 and S4), and one with labels at the end categories and middle category (S3). The original 9-point hedonic scale makes use of labelled categories, but a shift away from using labelled categories has been reported (Lawless & Haymann, 2010). One of the reasons for this shift may be the international use of the scales and thereby translation to other languages than English. Due to language- and cultural differences translation is not an easy task (Curia, Hough, Martínez, & Margalef, 2001), and an verbatim translation may not be possible or optimal. The scale applied in S2 and S4 was found applicable in another Danish study (Listov-Saabye, 2002), and in general consumers did not report problems with either of the 9-point-hedonic scales applied.

4.4 Analysis of questionnaire data

Several analytical methods exist for evaluating questionnaire data, and a collection of these have been used to analyse results from the different studies included in the thesis. This section will focus on Principle Component Analysis (PCA) and Partial Least Square Regression (PLSR), and compare performance of those methods to alternative approaches.

PCA is a fundamental method in multivariate data analysis, which generally is used to get a visual overview of data. It is a technique used to analyse interrelationships among a number of variables and to explain these variables in a smaller number of variables, principal components, with minimum loss of information (e.g. Næs, Brockhoff & Tomic, 2010; Piggot, Simpson & Williams, 1998). The first principal component accounts for as much of the variability in the data as possible. Each succeeding component in turn has the highest residual variance possible under the constraint that it is orthogonal to the preceding components.

In *PIV* and *PV*, PCA was applied to visualise relationships between attributes in descriptive sensory analysis. In *PV*, PCA was further used to visualise relationships between influential variables in FS measured “immediately after intake” and “one hour after intake”.

In PLSR, a model is established which describes the relationship between two sets of data (X and Y). X consists of more than one column variable, whereas Y can be one or several column variables. In PLSR the idea is to create, starting from a table with “p” variables, a set of “h” components with “ $h < p$ ”. The components are built so that they predict Y as well as possible. PLSR was used as a tool for variable identification in *PII*, *PIV* and *PV*. FS immediately after intake was used as Y-variable in *PII*, *PIV* and *PV*. Selected “during intake-“ (only *PII* and *PIV*) and “immediately after intake-” variables, socio demographic-, general behavioural- and attitudinal-variables were added as X-variables. In *PIV* a second PLSR model was built with FS measured one hour after intake as Y-variable, and “one hour after intake variables”, socio demographic-, general behavioural- and attitudinal variables as X-variables. In *PV*, PLSR was also used to study sensory attributes influencing SS. In this model SS was used as Y-variable, and intensity ratings of sensory attributes as X-variables.

From the PLSR, Variables Important in Projection scores (VIP scores) was calculated which summarises the importance of the X-variables for both the X- and Y-models. A VIP score of 0.8 was used as cut-off value; a VIP score between 0.8 and 1.0 was regarded moderate influential and a VIP above 1 highly influential (Eriksson et al, 2001; Wold, 1995).

Path modelling, also called Structural Equation Modeling (SEM), could have been used on consumer data to investigate the relationship between different constructs of data. This approach was previous applied on quality, price, value, satisfaction and behavioural data (Iacobucci, 2009). Compared to PLSR, SEM can bring clearer information about how variables relate to a construct and how different constructs relate to each other. In the present studies, SEM could have been used to study how e.g. SS, physical well-being, psychological well-being and demographics data related to FS. However, as the sub-aims of the present thesis (section 1.1) focus on the influence of product-, person- and context related factors in food satisfaction, PLSR was chosen.

One widely used approach within analysis of consumer data is cluster analysis. In cluster analysis, consumers are divided into a number of clusters according to one or more variables. Consumers are grouped in such way that the consumers within a cluster are more similar to each other than to the consumers in other clusters. Cluster analysis is a methodology used for studying patterns among individuals, and can be used to find clusters of consumers who prefer different products. For example, cluster analysis have been used to find clusters of consumers who preferred salmon either storage frozen, on ice or in modified atmosphere (Green-Petersen, Hyldig, Sveinsdóttir, Schelvis, & Martinsdóttir, 2009). In the studies conducted in relation to the present PhD project, cluster analysis could e.g. have been used to study demographic, general behavioural and attitudinal patterns among clusters of consumers with different level of SS or FS. However, as the number of consumers included in the respective studies was 132 as max. Dividing consumers into clusters would have resulted in very few consumers in each cluster. For that primary reason cluster analysis was not applied to data.

CHAPTER 5: FACTORS INFLUENTIAL IN FOOD SATISFACTION

In relation to the present PhD project it is hypothesised that satisfaction is a multidimensional concept influenced by “product-“, “person-“ and “context related” factors (section 1.1). As explained in section 3.1, the classification of “product-person interrelated” factors have been included as well. Thus, one of the focal points in the PhD project was to explore the influence of “product related-“, “product-person inter-related-“, “person related-“ and “context related-” response variables in FS, in different case studies.

PLSR was used to study response variables in relation to FS, and interpretation of influential response variables was based on VIP scores. A VIP score of 0.8 was used as cut-off value; a VIP score between 0.8 and 1.0 was regarded moderate influential in FS, and a VIP above 1 highly influential in FS (Eriksson et al, 2001; Wold, 1995). Table 1 shows: an overview of response variables found moderately and highly influential in FS, their VIP score and if the influence was positive or negative. Note, only response variables with a $VIP \geq 0.8$ are shown in the table. As can be seen from Table 1, both “product-person inter-related-“, “person related” and “context related” response variables were found influential in FS.

“Product related” response variables were investigated by studying: how sensory attributes related to SS, and how liking of sensory properties related to SS. These are not shown in Table 1 as they related to SS and not FS, but results from the respective studies are presented in section 5.1.1.

Table 1. VIP scores of response variables post intake found by PLSR to food satisfaction in the respective studies. Direction if the influence of each variable is indicated in the last column.

Response variables	S2	S3a	S3a 1 h.	S3b	S3b 1 h.	S4b	Direction
Product –person interrelated							
SS	3.0	2.9	3.5*	3.2	3.4*	3.6	Positive
Desire for other foods	-	-	-	-		-	
Yes					1.1		Negative
No					1.1		Positive
Drinkability						3.0	Positive
Reason ending							
Boredom	1.7	1.4		1.3			Negative
Satiating	1.4	1.1		1.5			Positive
Unpleasant		1.0		1.1			Negative
Product performance compared to expectations							
Worse	2.5	2.2		2.7			Negative
As				1.4			Positive
Better	2.2	1.5		1.6			Positive
Psychol. Well-being	-	-		-		1.4	Positive
Fulfilled expectations	1.8	0.8		3.2			Positive
Hunger	1.5	0.9	-	1.2	1.0	-	Negative
Fullness	1.8	-		1.2		0.8	Positive
Energy	-		1.6		2.6	1.1	Positive
Pleasant stomach feelings			1.5		2.2		Positive
Replace snack						1.6	Positive
Nausea						1.5	Negative
Person related							
Age < 25	-	-		1.1	1.2	0.9	ND
Age > 56	-	-		1.0	0.9	0.9	ND
BMI Normal weight	-		1.0			-	ND
BMI Over weight	-			0.9	0.9	-	Positive
BMI Obese	-	0.9	1.0			-	Negative
Education	-	-	-	-		-	ND
Lower secondary					0.9		Negative
Consumption frequency	-	-		-	-	-	ND
1-5 times per half year			1.0				Negative
General liking of food type	-	1.2	1.3	-	0.9	-	Positive
Attitude towards new foods	-	-	0.8	-	-	-	Positive
Context related							
Which meal				-			
Breakfast					0.9		Positive
Late dinner					0.9		Negative
With who				-			
Family					0.9		Negative
Colleagues					1.0		Positive

*measured as memory about SS

ND: No general Direction

As can be seen from Table 1, some response variables were highly influential in FS in all studies, while others were study-specific.

In all studies, “SS” was found highly influential in FS immediately after intake (all VIP scores \geq 2.9). “Memory of SS” was found highly influential in FS one hour after intake (VIP scores \geq 3.4). The importance of “SS” in FS is elaborated further in section 5.2.2.

Reason for ending intake was found highly influential in all the studies, where the response variable was measured. Ending the meal due to “sensory boredom” or “unpleasant feelings” influenced FS highly negatively, whereas ending the meal due to “satiation” influenced FS highly positively. Ending the meal due to “sensory boredom” can be interpreted as, the experience of sensory specific satiety before homeostatic satiety sets in. This topic is elaborated further in section 5.3.2.

In all studies where the response variables were included, “fulfilment of expectations” and “product performance relative to expectations” were found influential in FS. Results of product performance indicate that disconfirmed expectations is highly influential in FS, as delight (performance better than expected) influenced FS positively and disappointment (performance worse than expected) influenced FS negatively. The role of expectations in FS is discussed further in section 5.2.4.

Several response variables related to physical well-being after intake were found influential in FS. In several of studies, these response variables included: “hunger”, “full-ness”, “energy-level” and “pleasant stomach feelings” after intake. As expected, hunger after intake influenced FS negatively, and fullness influenced FS positively. These results harmonise with the main purpose of initiating a meal; to reduce hunger. Interesting, fullness was not only positively associated to FS for soups and yoghurt w/mueslis but also for fruit drinks. This could indicate that beverages which can reduce appetite are positively received by consumers. The indication is backed up by the finding that FS was positively associated with consumers’ feeling that the fruit drink could replace a snack. Further it was interesting that hunger was not one of the response variables mainly influencing FS one hour after intake. A possible explanation for this finding is that consumers expected satiety of yoghurt w/muesli products to be limited, and therefore, if they were hungry one hour after intake, it did not affect FS.

In all studies except S2, feeling energetic influenced FS one hour after intake positively.

Of the “person related” response variables, “general liking of the specific food type” was found to influence FS positively in S3a and S3b. “Age” influenced FS in S3b and S4b. In S3b consumers < 25 years rated FS more negatively, whereas consumers > 56 rated FS more positively. The opposite trend was seen in S4b. The age effect could indicate that the products are/should be targeted for different consumer segments. The effect of age is elaborated further in section 5.3.1.

“BMI” was found influential in FS in S3a and S3b, with obese rating FS more negatively. Wang (2001) found that obese was less sensitive to reward than overweight consumers, therefore, it is possible that obese in general does not experience satisfaction as other consumers do. However, an influence of BMI in FS was not found in S2 and S4.

“Context related” response variables were only studied in S4b, as context did not differ within the rest of the studies. One hour after intake, FS was influenced by “the meal at which the product was consumed”. Consuming the yoghurt w/muesli product for breakfast influenced FS positively, whereas consuming it as a late dinner influenced FS negatively. Several factors could have caused these findings. One possibility is consumers’ feeling of appropriateness of yoghurt w/muesli products at the given meal. In general, it seems reasonable that consuming yoghurt w/muesli for breakfast is more appropriate, than consuming it as a late dinner. However, as the variable (“which meals the product was consumed at”) only was found to influence FS one hour post intake, and not immediately after intake, another explanation might be that the products caused physical sensations, which were more desired in the morning than in the evening. E.g. a high energy level could be more satisfying in the morning than in the evening. However, this was not investigated in S4b. The social company during intake was found to influence FS. Eating with colleagues influenced FS positively whereas eating with family members influenced FS negatively. The influence of social eating context is discussed further in section 5.4.2.

Important to mention is that though a response variable is found to influence FS in all studies, generalisation must be done with caution. The results can be specific for the products involved in the respective studies and further studies are needed to clarify, if the results can be generalised to a broader range of products within the food types used and if results can be generalised to other food types.

In the following sections selected “product related”, “product-person inter-related”, “person-related” and “context related ” response variables will be discussed.

5.1 Product related factors

In the studies conducted in relation to the present PhD project, product related factors of importance for SS and FS were studied from two perspectives; a whole product perspective and a sensory perspective. From the whole product perspective, it was investigated, if the products caused significant differences in ratings of SS and FS. Findings were then related to descriptions of ingredients, nutritional content and/or energy content. From the sensory perspective, sensory descriptive analysis was used to find sensory attributes of importance for SS.

All products used in the respective studies were described by a sensory panel, but the choice of descriptive method differed. In S2 expert statements were obtained to establish a sensory profile of the soups. A clear disadvantage of the expert judgement was that statistical analysis could not be applied to data, and therefore the relation to SS relied on a comparison between description of sensory characteristics from the expert statements and results of statistical analysis for differences between products in SS. PLSR was applied to study association between sensory attributes and sensory satisfaction in S3a (unpublished) and S4b (*PV*). A description of the profiling done in S3a and S4b can be found in *PIV* and *PV* respectively.

In the following, results on differences in FS and SS in S2, S3a and S3b, and S4 will be presented. For S3 and S4 results on the sensory attributes influence in SS will further be presented.

5.1.1 Product characteristics and sensory differences of importance in SS and FS

In S2 two variants of a creamy chicken soup was used; A, a basic creamy chicken soup and B, the same basis soup added chicken, vegetables, croutons and parsley. Pictures of the soups can be seen in Figure 6. For more details see *PII*. A main product effect was found for SS and FS, with Soup variant B rated significantly higher than variant A (for FS and SS $p < .0001$).



Figure 6. Pictures of the soups. To the left: soup A. To the right: soup B

In S3 four yoghurt w/muesli products were used; MB, MN, TB, TN, consisting of two variants of yoghurt (M, T) and two variants of muesli (B, N). For more details see *PIV*. Pictures of the yoghurt and mueslis can be seen in figure 7.

In S3a (lab-context) a significant difference between products was found for SS ($p = .011$), FS immediately after intake ($p = .009$), memory of SS ($p = .003$) and FS one hour after intake ($p = .029$). When analysing if the effect could be regarded a yoghurt, muesli or an interaction effect, results showed that differences could be regarded a muesli effect (all p -values $< .01$), with the nut-containing muesli rated highest on a 9 point scale.

In S3b (natural-context), no significant product difference was found for consumers' ratings of FS immediately after intake and one hour after intake.



Figure 7. Pictures of the yoghurt w/muesli products. The yoghurts; to the left: variant T (highest energy), to the right: variant M (lowest energy). The mueslis: to the left: variant N (nuts), to the right variant B (berries).

In S3a, the influence of sensory attributes in SS was analysed through PLSR and VIP scores. SS was included as Y-variable and sensory attributes as X-variable. A two-component PLSR-model had a Q^2_{cum} of 0.729 indicating a good model (Figure 8). Factor 1 explained 77.9% and 92.5% and factor 2, 6.8% and 6.0%, of the variance in X and Y, respectively. The model showed that SS correlated positively to yoghurt w/muesli TN and MN characterised by: a grainy and nutty odour, sweet, caramel, nutty and grainy flavour. SS correlated negatively to the sensory attributes: crispy texture, sweet and berry odour and colour set off from muesli to yoghurt. These attributes were mostly related to product MB and TB. Analysis of VIP scores showed that all attributes except astringency, solidity and intact muesli had a VIP score above 0.8, indicating that these contributed the most to the model.

Results showed that differences could be regarded a muesli effect for all attributes (all p-values < .01) except “intact muesli”, which could be regarded a yoghurt*muesli interaction effect (p = .005).

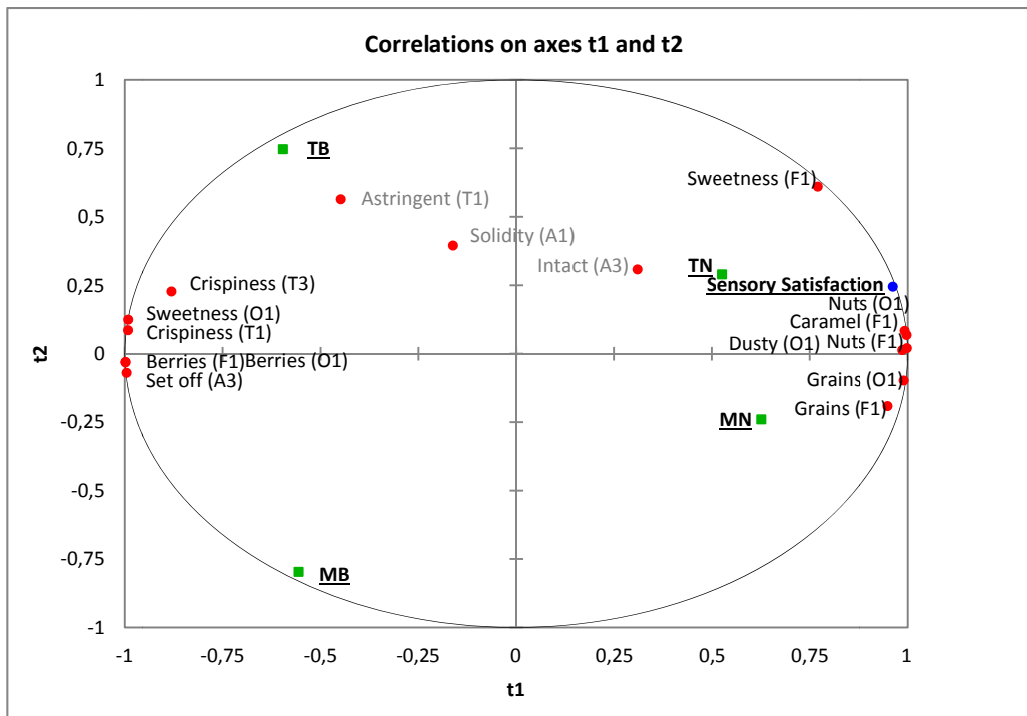


Figure 8. PLSR model of sensory satisfaction (Y-variable, underlined) and sensory attributes (X-variables) with indication of products; TB, MB, MN and TN (underlined). Attributes with a VIP score ≥ 0.8 are written in black, VIP scores < 0.8 are written in grey

In S4b four apple-cherry fruit drinks were used varying in: type of sweetener used and if fibres (β -glucans) and lime zest aroma had been added. Product characteristics can be seen in Table 2 and pictures of the fruit drinks can be seen in Figure 9.

Table 2. Fruit drink characteristics

Product	Sweetener	Level of added lime zest aroma	Level of added fibre (β -glucans)	Total energy content (kJ/100ml)
S	Sucrose, (26g/L)	0g	0g	382.0
A	Stevia, (0.09g/L)	0g	0g	297.5
B	Stevia, (0.09g/L)	1ml/litre	0g	297.5
D	Stevia, (0.09g/L)	1 ml/litre	10g/L	317.0



Figure 9. Pictures of the apple-cherry fruit drinks. From left: B, D, S and A

Significant product differences were found for SS ($p < .001$) and FS immediately after intake. Post hoc test showed that fruit drink D was rated significantly lower than A and S but not significant lower than B. No difference between fruit drinks were found for FS at time 10-, 20-, 30- and 40 minutes after intake.

The influence of sensory attributes in SS was analysed through PLSR and VIP scores. SS was included as Y-variable and sensory attributes as X-variable. A two-component PLSR-model had a Q^2 cum of 0.974 indicating a good model (Figure 10). Factor 1 explained 76.5% and 95.7%, and factor 2, 18.7% and 3.6%, of the variance in X and Y, respectively. The model showed that SS correlated positively to fruit drink A (stevia-sweetened, without lime zest aroma and fibres) and S (sucrose sweetened, without lime zest aroma and added fibres) characterised by: a sour taste, a clear and red appearance, a cherry, apple and boiled fruit aroma and flavour. SS correlated negatively to fruit drink D (stevia-sweetened, with lime zest aroma and added fibres) characterised by: a creamy mouth-feel and thick texture and a lime zest flavour and aroma. Analysis of VIP scores showed that all attributes except sweet taste and liquorice aftertaste had a VIP score above 0.8, indicating that these attributes contributed the most to the model.

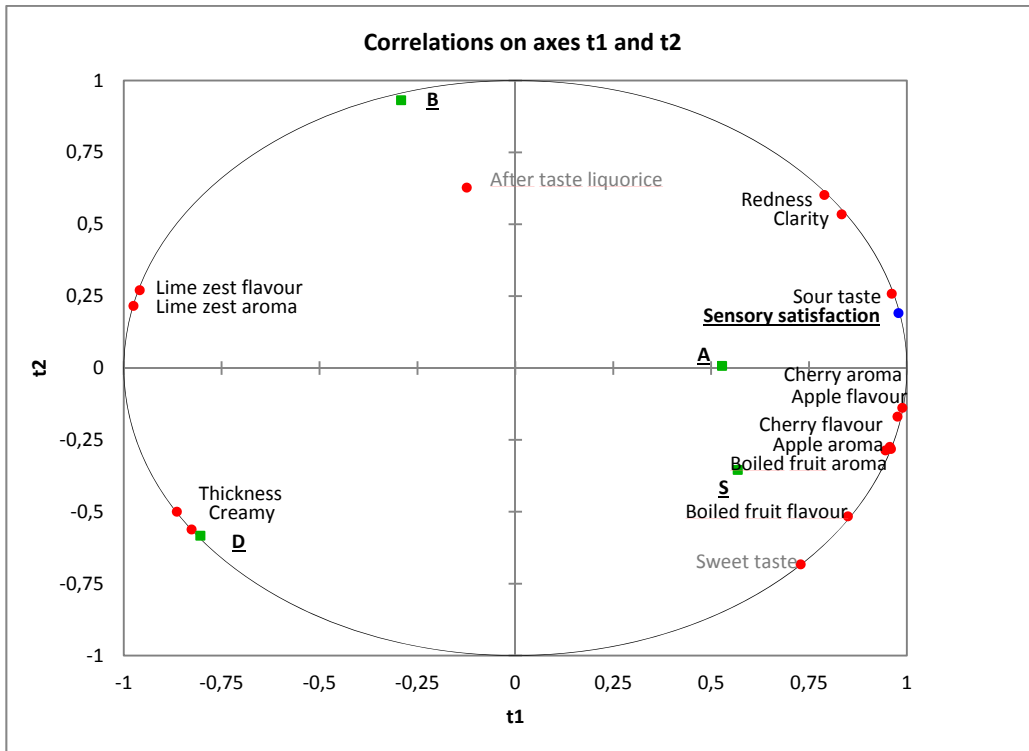


Figure 10. PLSR model of sensory satisfaction (Y-variable, underlined) and sensory attributes (X-variables) with indication of products; A, B, D and S (underlined). Attributes with a VIP score ≥ 0.8 are written in black, VIP scores < 0.8 are written in grey.

No literature is directly comparable to the results found here about how the single sensory attributes relate to SS. Nevertheless, the importance of sensory properties for hedonic perception of foods and food behaviour is evident when observing the broad range of studies and models focusing on: sensory properties and acceptance (e.g. Harper, 1981; Land, D.G., 1983; Tuorila, 2007), sensory properties and preference (e.g. Khan, 1981), sensory properties and food behaviour (e.g. Cardello, 1996; Fürst et al, 1996; Connors et al, 2001; Mojet, 2007) and liking as a determinant for intake (e.g. Drewnowski & Hann, 1999).

5.2 Product-person interrelated factors

Several factors within the category “product-person inter-related factors” were rated in the studies conducted in relation to the present PhD, Table 3 provides an overview.

In this section selected response variables will be studied in detail and compared to established literature within the area.

Table 3. Overview of product-person inter-related determinants to food satisfaction studied in the respective quantitative studies. Only response variables immediately after intake are included

Product-person inter-related determinants (Papers)	S2	S3a Lab	S3b Natural-context	S4a	S4b
Overall liking	X	X	X	X	X
Liking of appearance	X	X	X	X	
Liking of odour	X	X	X	X	
Liking of taste	X	X	X	X	X
Liking of textue	X	X	X	X	X
Liking of aftertaste	X	X	X		X
SS	X	X	X	X	X
Reason for ending intake	X	X	X		
Fullfillment of expectations	X	X	X		
Product performance	X	X	X	X	
Hunger	X	X	X		X
Fullness	X	X	X		X
Desire for other foods	X	X	X		X
Desire to eat again	X	X	X		
Physical well-being	X	X	X		X
Psychological well-being	X	X	X		X
Energy level		X	X		X
Drinkability					X
Drinking pleasure					X
Feel in throat					X
Feel in stomach					X
Thirsty					X
Replace snack					X
Nausea					X
Energy level					X
Reflux					X

5.2.1 The importance of liking of: appearance, odour, taste and texture in sensory satisfaction

When rating SS, consumers were asked to consider the all four sensory properties; appearance, odour, taste and texture. Thereby, consumers could be expected to pay attention to all four sensory properties when rating SS, but the relative importance of each property in SS could vary. In the S4a it was investigated if consumers paid equal attention to liking of appearance, odour, taste and texture when evaluating SS. The results could be used to guide product developers in which properties to emphasize the most, when developing or optimising their products (H. R. Moskowitz & Krieger, 1992). Further, the results add to our knowledge about the SS-term by approaching, which sensory properties consumers primarily pay attention to.

For a description of the method see *PVI*, where more results also are presented. Table 4 shows the raw and relative slope means for the relation between “SS” and “liking of each sensory property”. The relative slopes can be used to interpret which properties consumers primarily pay attention to when evaluating “SS”. The closer a relative slope mean lays to 1, the more attention did consumers paid to liking of the specific property”. From Table 4 it can be seen that consumers primarily paid attention to “liking of taste” when rating SS. In support of the results found in S4a, a study on fruit pies found that taste provided the most important sensory input for overall liking (H. R. Moskowitz & Krieger, 1992). Further, the contribution of liking of sensory properties for overall liking was investigated in a case study using six food product categories (Howard R. Moskowitz & Krieger, 1995). In all food categories, taste provided the most important sensory input for overall liking.

Table 4. Raw and relative mean slopes between liking of: appearance, odour, taste and texture respectively, and sensory satisfaction

	t	Sensory satisfaction		
		95% CI	Raw mean slope	Relative mean slope
Appearance	5.01	0.33 – 0.76	0.54	0.23
Odour	2.33	0.06 – 0.72	0.39	0.16
Taste*	11.11	0.72 – 1.03	0.88	0.37
Texture	4.02	0.28 – 0.83	0.55	0.23

*to be understood as flavour

Though the results show a trend in which sensory properties consumers primarily pay attention to, individual differences existed. Moskowitz and Krieger (1992) found that 73 out of 98 consumers followed the pattern: taste > texture > appearance, when analysing the importance of liking of sensory properties for overall liking. Moskowitz and Krieger (1995) showed that the importance likewise was: taste > texture > appearance, for the majority of consumers (43%). In S4a (*PVI*) ranking showed that for the majority of consumers, 37%, taste likewise provided the most important sensory input when rating SS. 19% of consumers rated appearance, odour and texture, respectively as the most important sensory input when rating SS.

5.2.2 The influence of sensory satisfaction in food satisfaction

The association between SS and FS was investigated in all studies conducted in relation to the PhD. From the focus group interviews (S1) it was found that consumers agreed on the fact that sensory properties were the primary determinants to FS, but other determinants influenced FS as well.

Below are quotes where participants compare the importance of a positive sensory experience to other factors of importance in FS. The quotes are published in *PI*.

”when you make food, you should be inspired by your grandparents. They didn’t think about it (health) because they made food with cream. It was whipping cream, not low fat products, and it tastes a lot better.” (health vs. sensory experience).

”I like something healthy and it’s mostly what I choose, but there’s something about the other (the unhealthy) that’s really delicious. What about quality of life? What if I think I’ll be happy eating this? If it makes me happy then it’s good.” (health vs. Sensory experience as a source of quality of life).

”I’d rather go without, ...rather go away hungry than have a bad sensory experience.” (satiety vs. sensory experience).

Results from the quantitative studies (S2, S3 and S4), based on PLSR models showed that SS was highly influential in FS (Table 1).

For the purpose of illustrating the relation between SS and FS in this thesis, Pearson’s correlation test was conducted (unpublished). Results are shown in Table 5. In all quantitative studies, a clear positive correlation was found between SS and FS, irrespectively of whether FS was measured “immediately after intake” or “one hour after intake” (= .706-.914, $p < .0001$). Interesting, the correlation between SS and FS remained high one hour after intake. This finding indicates that though other sensations influence FS post intake, SS is still highly associated to FS. Further interesting, the correlation between “SS measured through memory” and “FS one hour after intake” is higher than when SS are measured during intake (though only marginally higher). One could hypothesise that memory of SS is an idealised picture of how the actual hedonic experience was perceived. No studies have been found that could confirm or disconfirm this hypothesis. Studies on memory of foods experiences have so far been focused at investigating: if sensory attributes are remembered equally (e.g. M. A. Köster, Prescott, & Köster, 2004; Morin-Audebrand et al., 2009), if food is remembered equally well across age-groups and liking of the particular food (e.g. Laureati et al., 2008), or the part of an affective experience which is most important in memory (peak, end affective experience, duration of affective experience etc.) (e.g. Rode, Rozin, & Durlach, 2007).

Table 5. Pearson’s correlation between sensory- and food satisfaction in study 2, 3a, 3b and 4b. Sensory satisfaction is measured during food intake and one hour after intake, though memory. Food satisfaction is measured immediately after intake, 40 min. post intake and one hour post intake depending on the respective study

	S2	S3a		S3b		S4b	
	FS Immediately post intake	FS Immediately post intake	FS 1 hour post intake	FS Immediately post intake	FS 1 hour post intake	FS Immediately post intake	FS 40 min. post intake
SS	.895	.861	.845	.887	.870	.914	.706
p-value	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001	< .0001
SS-memory	-	-	.908	-	.924	-	-
p-value	-	-	< .0001	-	< .0001	-	-

5.2.3 Reason for ending a meal

The hedonic response to a particular food begins during the early stages of sensory processing. If the food does not look or smell good it is unlikely to be tasted or eaten. As food is eaten, pleasantness of its appearance, smell, texture and taste decreases, whereas other foods remain pleasant. This phenomenon is known as “sensory specific satiety” (SSS) (B. Rolls, 1986). Two distinguishable components of pleasure of eating have been identified; “liking” measured by subjective hedonic ratings and “wanting” measured by motivation or desire to eat (Berridge & Robinson, 2003; Berridge, 2014). Under normal circumstances liking and wanting operate together (Havermans, 2011). Consumers’ awareness of the two different dimensions has been suggested to be minimal, likewise has the importance of the shift in pleasantness for food intake (Mook & Votaw, 1992). Mook and Votaw (1992) conducted a series of studies where subjects indicated their main reason for ending meals. As the majority indicated “fullness” as the primary reason, and very few indicated “the food stopped tasting good” or “the food tasted less good”, the authors concluded that the hedonic shift were of little importance in terminating a meal. However, a limitation in this study was that no meals were presented (Mook & Votaw, 1992), so the subjects’ answers were based on memory rather than actual experience.

In S2, S3a and S3b consumers were asked to indicate their “reason for ending intake”. Responses were collected using the categories: a) “I was satiated” b) “the food bored me” c) “the food felt unpleasant” d) “my conscious told me not to continue eating” and, e) “other reason”, followed by a clarification. Ending the meal due to “satiation” was meant to reflect; a decrease in homeostatic hunger, wanting, which caused food intake to end. Ending the meal due to “boredom” was on the other hand meant to reflect that intake ended due to a decrease in pleasantness despite homeostatic hunger might still be present, SSS. In contrast to the findings by Mook and Votaw (1992), consumers did differentiate in their reason for ending intake. Our results support previous findings by Hetherington (1996), who likewise found the response variable, “got tired of the food”, as an important reason for ending intake, and associated the effect to an increase in SSS.

5.2.4 Expectations and product performance relative to expectations

Consumers’ expectations, of either sensory or hedonic characteristics, can be generated by a variety of factors and play an important role for degree of satisfaction (Costell et al., 2010).

Deliza and MacFie developed a model of the role of expectations in food choice and sensory perception (Deliza & Macfie, 1996). The first part of the model demonstrates the role of expectations on food choice. As products used in the respective studies conducted in relation to this PhD, all were chosen beforehand, this part of the model will not be elaborated. Instead focus will be on the last part of the model, focusing on the role of expectations in satisfaction. Consumers create expectations about food based on either: verbal or written information about the food (memory of foods alike), the physical product (product sample served blind), the product image (picture of product or information about the product) or the total product (physical product + product image). Expectations reflect a subjective standard of product performance both sensory and hedonically. When the food is tasted and its sensory attributes perceived, expectations will be confirmed or disconfirmed. Confirmation occurs when performance matches the standard, and disconfirmation

occurs when expectations and standards does not match. Deliza and MacFie (1996) predicted that confirmed expectations lead to a satisfaction, whereas disconfirmed expectations lead to either satisfaction or dissatisfaction, depending on whether the disconfirmation was positive or negative. Positive disconfirmation was believed to cause satisfaction and negative disconfirmation was believed to cause dissatisfaction. The satisfaction outcome was believed to affect the next product experience by contributing to either raised or lowered expectations.

In the studies conducted in relation to the PhD, it was of interest to study if consumers' satisfaction could be explained according to Deliza and Macfies model. In the respective studies consumers could have based their expectations about the products on; I) prior experience with foods alike II) the information given during recruitment, verbal introduction to the study and written information in the questionnaires, and III) when seeing the products before tasting and eating. In S2 and S3 expected liking was measured knowing the food type, but before perceiving any of the foods sensory characteristics. In S4 consumers rated expected liking while perceiving the fruit drinks appearance. The difference could have affected the discrepancy between what was expected, and what was experienced.

Relevant response variables included: "expected liking", "overall liking", "sensory satisfaction", "product performance relative to expectations" and "food satisfaction". All response variables were measured on a 9 point-scale, except "product performance relative to expectations" which was rated through the categories; "worse than expected", "as expected" and "better than expected" (see respective questionnaires in appendix 1).

In the following consumers ratings of expectations and hedonic experience will be described using S2 as an example.

Table 6 summarises consumers' ratings of "expected liking", "overall liking", "sensory satisfaction" and "fulfilment of expectations" in S2. Recall that the study was a cross-over study where subjects consumed two versions of a creamy chicken soup; one variant per day. On the first day, no difference was found in ratings of "expected liking", between soup A and B, indicating a similar level of expectations prior to the study. "Overall liking" of soup A was significant from "expected liking" ($p = .023$) indicating negative disconfirmed expectations. "Overall liking" of soup B was not significant from the expected liking rating indicating confirmed expectations. On the second day, consumers exposed to soup B (those who were exposed to soup A on day1) gave significant lower ratings of "expected liking" compared their ratings of "expected liking" on day 1 ($p = .027$). "Expected liking" on day 2 was rated similar to "overall liking" ratings on the first day. Consumers exposed to soup A on the second day also rated "expected liking" comparable to "overall liking" ratings on the first day. These findings indicate that regardless of whether the former experience confirmed or disconfirmed expectations, consumers adjusted their expectations in the direction of the experience from the first day. This finding supports the predictions done by Deliza and Macfie (1996). On the second day, "overall liking" ratings of soup A and B both showed indication of disconfirmed expectations; negative for soup A ($p = .039$) and positive for soup B ($p < .0001$).

Table 6. Mean ratings of: expected liking, liking, sensory satisfaction and fulfilment of expectations for soup A and B, on the first and second day of evaluation, respectively

1st day	Soup A	Soup B
Expected liking	7.0 (± 0.7)	6.8 (± 1.0)
Liking	6.5 (± 1.3)	7.0 (± 1.7)
Sensory satisfaction	5.7 (± 1.5)	6.6 (± 1.8)
Fulfilment of expectations	7.5 (± 0.9)	6.8 (± 1.7)
2nd day	Soup A	Soup B
Expected liking	6.9 (± 1.2)	6.5 (± 1.2)
Liking	6.4 (± 1.5)	7.4 (± 0.6)
Sensory satisfaction	5.0 (± 2.0)	7.5 (± 0.6)
Fulfilment of expectations	4.9 (± 1.9)	5.2 (± 1.8)

The literature on expectations presents four main psychological theories, describing how disconfirmed expectation can effect sensory perception and consumer satisfaction; *Assimilation*, *Contrast*, *Assimilation-Contrast* and *Generalised Negativity* (Anderson, 1973; Deliza & Macfie, 1996).

Assimilation Theory (also called cognitive dissonance) states that any discrepancy between expectations and product performance creates a kind of psychological discomfort. To reduce the discomfort the consumer alters the perception in the direction of the expectation.

Contrast Theory assumes that when expectations are disconfirmed, consumers exaggerate the disparity between the expectation and perception. For instance, according to this theory if consumers have low expectations which are disconfirmed, it will result in higher consumer satisfaction. On the other hand high expectations which are disconfirmed will reduce consumer satisfaction. Contrast theory can therefore be regarded the reverse of assimilation.

In the *Assimilation-contrast Theory* the size of discrepancy affect whether assimilation or contrasting effects will occur. If the disparity is small (limit of acceptance is subjective) the evaluation will follow assimilation and move product evaluation in the direction of expectations. On the other hand if the disparity is large, contrasting effects will occur.

Generalised Negativity supposes that any discrepancy between expectation and product performance result in a generalised negative hedonic state, causing the product to be rated less favourable than if expectations had been met.

Deliza and MacFie (1996) created an illustrative representation of the four models of expectations. The representation is shown in Figure 10.

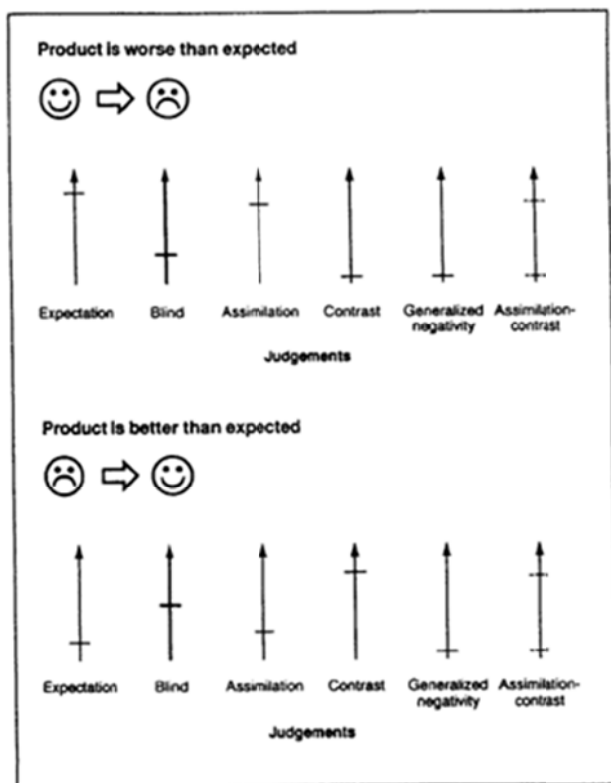


Figure 10. Illustrative representation of the four models of expectations (Deliza & Macfie, 1996)

In the paper by Deliza and Macfie (1996), empirical evidence was reviewed to find evidence for the expectation theories. They found several studies supportive of the “Assimilation Theory” (Allison & Uhl, 1964; Anderson, 1973; A. V. Cardello & Sawyer, 1992; Schifferstein, Kole, & Mojet, 1999). Among those were a classical marketing study focusing on the role of expectations created through brand, on hedonic ratings of cola beverages (A. V. Cardello & Sawyer, 1992). The researchers manipulated the experiment, so a) consumers expected a cola they liked and b) consumers expected a cola they disliked. The results showed lower hedonic ratings when consumers expected a product they disliked, compared to when the same product was tasted blind. Consumers who expected a product they liked, rated liking higher than when the same product was tested blind. Both situations showed assimilation effects. Only a few studies reported contrast effects (A. V. Cardello & Sawyer, 1992; Yeomans, Chambers, Blumenthal, & Blake, 2008; Zellner, Strickhouser, & Tornow, 2004). As the example above also illustrates, the study of expectations is often applied in conditions different from those usually found within sensory science. Expectations are much more often investigated within marketing, to study the effect of extrinsic product characteristics e.g. labeling on hedonic product perception. It is not possible to apply the psychological theories about disconfirmed expectations to the results in our study, as the consumers only evaluated each soup type once. In order to estimate how expectations might have affected hedonic ratings, each soup type could have been evaluated twice with different levels of expectations (preferably a baseline measure conducted without expectations).

In the present studies it was of interest to study how confirmed and disconfirmed expectations related to satisfaction.

From Table 1 it can be seen that “fulfilment of expectations” and “product performance” influenced FS in S2, S3a and S3b. The response variable “fulfilment of expectations” measured degree of fulfilment on a 9 point scale, where: ratings < 5 (not fulfilled) indicated disconfirmed expectations, rating 5 indicated neither confirmation nor disconfirmation, and ratings > 5 (fulfilled) indicated confirmed expectations. The response variable “product performance” measured, if the experience was: “worse than expected” indicating negative disconfirmation of expectations, “as expected” indicating confirmation, and “better than expected” indicating positive disconfirmation.

However, as mentioned in *PII* and *PIV* it can be questioned, if the consumers interpreted the question about “fulfilment of expectations” as intended. Note that no matter if consumers found the product worse- or better than expected, ratings should be < 5. Indications that consumers misinterpreted the question can be seen from Table 6. For example, after consuming soup A on day 1, consumers indicated that their expectation were fulfilled with an “expected liking”-rating of 7.5, despite “overall liking” was rated significantly lower (6.5) than “expected liking” ($p = .023$).

Another example, after consuming soup B on day 2 consumers indicated that their expectations were neither fulfilled nor unfulfilled (rating 5.2), though “overall liking” (rating 7.4) was rated significantly higher than “expected liking” (6.5) ($p < .0001$). Another indication comes from analysing individual relations between consumers ratings of “fulfilment of expectations” and “product performance”(Table 7). From Table 7 it can be seen that when a soup was rated between 1 and 4 for “fulfilment of expectations” 95% of consumers used the response category “worse than expected” to rate the same soup. When ratings were between 6 and 9, 68% of consumers indicated than the soup was “better than expected”. This finding indicates that consumers most likely passed their subjective hedonic experience of the product onto the rating of “fulfilment of expectations”, resulting in “fulfilment of expectations” being interpreted as degree of product performance.

Table 7. Percentage of consumers rating a soup according to the categories: “worse than expected”, “as expected” and “better than expected” when ratings of “fulfilment of expectations” were between 1 and 4, 5 or between 6 and 9, respectively

	Fulfilment of expectations		
	Rating 1-4	Rating 5	Rating 6-9
“Worse than expected”	95%	25%	8%
“As expected”	5%	37.5%	24%
“Better than expected”	0%	37.5%	68%
Total	100%	100%	100%

The response variable “product performance” reflected the relation between consumers’ “expected liking” ratings and “overall liking” ratings better. Figure 11 shows the frequency of consumers rating the soups “worse than expected”, “as expected” and “better than expected” when consuming soup A and B, respectively on day 1 and day 2. When comparing consumers ratings of “expected liking” and “overall liking” (Table 6) to Figure 11, it can be seen that when ratings of “overall liking” were higher than ratings of “expected liking” (soup B, day 1: $p = NS$ and soup B, day 2: $p < .0001$), more consumers used the category “better than expected” (Figure 11b and 11d). When

“overall liking” were rated lower than “overall liking” (soup A day 2: $p = .039$) more consumers used the category “worse than expected” (Figure 11c).

The same tendencies were found in S3 (not illustrated), but not studied in detail in S4. As a consequence future studies, are recommended either to use a specific phrasing of the question about “fulfilment of expectation” or to leave out the question and only use the question about “product performance”.

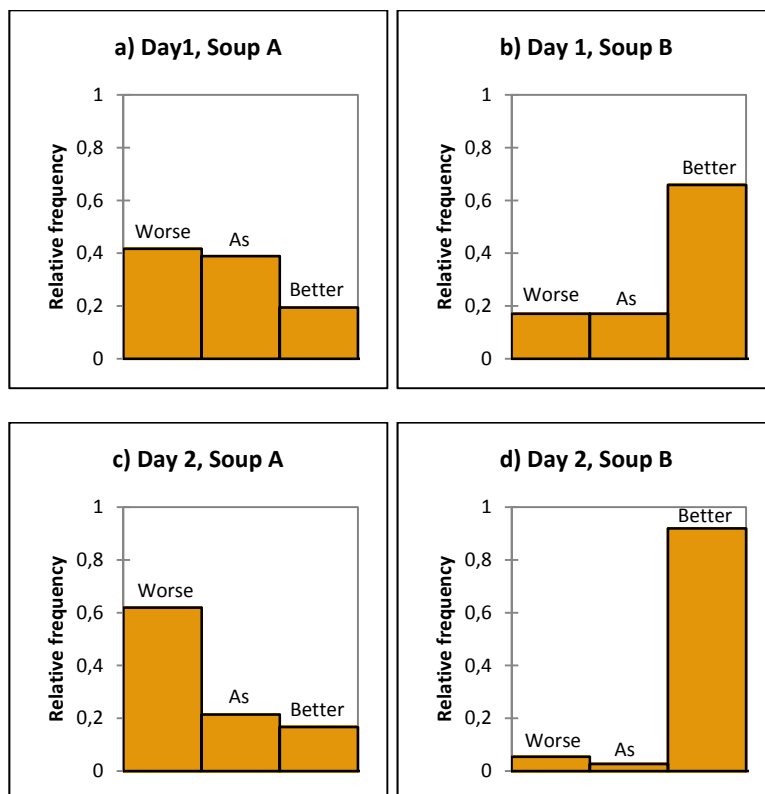


Figure 11a-d. Frequency of consumers using the response category “worse than expected”, “as expected” and “better than expected” on a) day 1 for soup A, b) day 1 for soup B, c) on day 2 for soup A and d) on day 2 for soup B.

In support of Deliza and Macfie’s (1996) predictions about confirmed / disconfirmed expectations and satisfaction. Product performance “worse than expected” was found to influence FS negatively and product performance “better than expected” to influence FS positively, in all studies (see Table 1). Further, product performance “as expected” was found to influence FS positively, as predicted by Deliza and Macfie (1996).

5.3 Person related factors

Several factors within the category “person related factors” were rated in the studies conducted in relation to the present PhD, Table 8 provides an overview.

In this section the response variable “age” will be studied in detail and compared to established literature within the area.

Table 8. Overview of person related determinants to food satisfaction studied in the respective quantitative studies

Person-related determinants (Papers)	S2	S3a Lab	S3b Natural-context	S4a	S4b
Gender	X	X	X		X
Age	X	X	X		X
BMI	X	X	X		X
Education	X	X	X		X
Consumption frequency	X	X	X		X
General liking of food type	X	X	X		X
Attitude towards new foods	X	X	X		X

5.3.1 Age

To study the effect of age on ratings of SS and FS, consumers were divided into four groups: < 25 years, 25-40 years, 41-55 years and ≥ 56 years, and mixed models with subjects as random effect and age-group as fixed effect was applied to data. Note, in *PIII* and consumers were divided into two age groups, but for the sake of comparability in the present thesis, data was re-analysed with the four mentioned age groups.

No identical trend was seen across studies. In S4b significant lower SS and FS (immediately- and 40 minutes after intake) ratings were found on fruit drinks, as consumers’ age increased (all $p < .04$). From *PV*, figure 3 it can be seen that the youngest age group could be regarded a main (positive) driver of FS, and the oldest age group a main (negative) driver FS. The negative effect of aging was supported in S2, where FS ratings likewise were found to decrease with consumers’ age. However, in this study differences were not significant. In S3 the effect of age group on SS and FS immediately after intake and one hour after intake of yoghurt w/mueslis was studied in both sub-studies, S3a and S3b. In S3a no effect of age group was found on either of the satisfaction measures. In S3b a significant effect of age group was found (all $p < .001$), where SS- and FS-ratings increased with age.

The effect of age seen in the respective studies is believed to be caused by several factors. First, the fact that age did not seem to have a similar direction (neither consistently positive nor negative) across studies indicate that the effect is product specific; some products are “preferred” by the older age groups, other products by the younger age group and some are equally preferred across age groups.

Second, the fact that S2 and S4b showed a negative correlation between age group and SS and FS could be caused by the general aging effect on perception ability. There is abundance of evidence that aging affect the perception of odour with elderly perceiving odours as less intense compared to younger subjects (e.g. de Graaf, van Staveren, & Burema, 1996; Murphy, 1983). Vantoller and Dodd (1987) suggested that the olfactory function decline with 20% between the ages of 20 and 80 years. Contradicting findings have been reported about the effect of age on taste perception. When tastants were dissolved in water, studies have shown a diminished sensitivity with increasing age (Mojet, Heidema, & Christ-Hazelhof, 2003), whereas little or no age effect was found, when similar tastants were dissolved in food (Adam Drewnowski, 1996; Mojet et al., 2003; Schiffman, Sattely-Miller, Zimmerman, Graham, & Erickson, 1994; Zallen, 1990). Changes in sensory acuity with age are presumed to influence the appreciation of foods, but data in support of this notion is generally lacking (de Graaf et al., 1996; Kremer, Mojet, & Kroeze, 2007; Mattes, 2002). If a relationship between sensory acuity and food appreciation exists, it could explain why elderly subjects show higher preference for flavour enhanced foods as reported by Schiffman and Warwick (1993). De Graaf and colleagues (1996) investigated differences in perceived intensity and pleasantness among young and elderly subjects using four food stimuli in five flavour concentrations each. Findings from their studies show that elderly needed higher concentrations to perceive a flavour as intense as younger subjects. Further they showed that elderly subjects had higher optimal preferred flavour concentrations, but size of the difference between younger and elderly subjects in optimal preferred concentration was product/flavour specific. This seems to support that the age can have an effect on hedonic appreciation of foods, and can explain why no similar trend of age was found across studies conducted in relation to the PhD project.

Third, the ageing effect on perception ability is most likely not the only factor influencing appreciation of foods. Other non-sensory factors are believed to influence as well. For example, a generation effect rather than an age affect is a possible explanation. One assumption could be that a generation brought up during times of limited food supply find greater pleasure with these foods even after the supply has normalised. However, common for all factors is that data is lacking and therefore further research is needed.

5.4 Context related factors

The dictionary defines context as “the circumstances in which an event occur; a setting” (The American Heritage Dictionary of English Language, 2000). Focusing on foods, these contextual conditions can occur, a) in the past, e.g. the effect of yesterday’s food choice on today’s choices, or the effect of early exposure on today’s food preferences b) in the future, e.g. fear of gaining weight on food choices, or c) simultaneous, which most research focuses on (King, Weber, Meiselman, & Lv, 2004), and are in focus in this section. Research suggests that at least four major concurrent context effects can alter the perception of food during consumption; its function as a meal component, the environment, the social interaction during consumption, and food choice freedom. Most of these contextual factors are controlled when conducting studies in controlled laboratory settings. But a tendency that is becoming increasingly apparent is, excluding these variables from research may cause oversimplified and incomplete results, which stress a need for studying food consumption in real contexts (Hellemann & Tuorila, 1991; H. L. Meiselman, 1992). That this viewpoint receives support is apparent from the increasing number of studies conducted in realistic settings (e.g. Mela, Trunck, & Aaron, 1993; Zandstra, de Graaf, & van Trijp, 2000). This section of the thesis discusses the effect of test location and social context found in the studies conducted in relation to this thesis, and compare findings to previous research. Further the section deals with appropriateness, a concept introduced by Schutz in 1988 (H. Meiselman, Frewer, & van Trijp, 2006) and used in several studies since, including some of the studies conducted in relation to this thesis. The context effects “meal component” and “food choice” will not be discussed in detail in this thesis, but written shortly, studies of “meal component” have found that consumers rate meal components different, depending on whether the meal component is studied separately or in combination with other meal components (e.g. Eindhoven & Peryam, 1959). Studies of “food choice” have found that consumers rate meals different, depending on whether the meal is chosen by the consumer or dictated by the study (Kramer, Leshner, & Meiselman, 2001). Table 9 provides an overview of the context related determinants to FS studied in the present PhD project.

Table 9. Overview of context related determinants to food satisfaction studied in the respective quantitative studies

Context-related determinants (Papers)	S2	S3a Laboratory context	S3b Natural context	S4a	S4b
Physical location		X	X		
Social company			X		
Time of day	X		X		
Appropriateness	X	X	X		

5.4.1 Test location

Previous research has found that when identical foods are served in different locations, acceptance of the food can be very different (de Graaf et al., 2005; King et al., 2004; H. L. Meiselman et al., 2000). Meiselman and colleagues conducted two studies that demonstrated the effect of location on hedonic ratings (H. L. Meiselman et al., 2000). They found consistently higher ratings of otherwise identical foods when consumed in a restaurant than when consumed in a cafeteria. One of their studies further showed that ratings of foods served in a laboratory were in-between the ratings of foods served in the cafeteria and the restaurant. King and colleagues (2004) studied the effect of meal situation, social interaction, physical environment and choice on food acceptability of three meals, with two variants per meal. The context effects were added sequentially over five tests, so that all context effects were present at test five. A sixth test was added to compare the results to a “real life” situation. Focusing on the effect of test location, they compared a laboratory facility to a mocked restaurant and a mocked restaurant to a real restaurant. They found that location had an effect on acceptability, but the effect and whether it was positive or negative depended on meal type and variant (King et al., 2004). Two studies have to my knowledge compared the hedonic ratings of products conducted at a sensory laboratory to hedonic ratings conducted in-home. Kennedy et al (2004) found higher ratings of overall liking of chicken when evaluated at home compared to when evaluated in sensory laboratory (Kennedy, Stewart-Knox, Mitchell, & Thurnham, 2004). Pound and colleagues found no effect of data collection context on overall liking of chocolates when evaluated in central location, in-home, a teaching laboratory and a sensory laboratory (Pound, Duizer, & McDowell, 2000).

In the studies conducted in relation to this thesis, the effect of test location, laboratory versus natural context, on FS was studied in *S3* and reported in *PIII*. A main effect of location was found on FS rated immediately after- and one hour after intake. In contrast to the study by Kennedy et al (2004) yoghurt w/ muesli products were rated higher when consumed in the laboratory context than in the natural context. Analysis of consumers’ general attitude towards foods showed that consumers participating in the laboratory test on average had a more positive attitude towards foods than the consumers participating in the laboratory test. For these analyses the variables studied were: general liking of yoghurt w/muesli products, general attitude towards meals, general food liking and general attitude towards new foods. Ideally, the study of location differences should be done by testing the same people in different locations, as this would result in only one of the three variables (food, eater, environment) being varied.

As a part of study *S3b*, consumers were asked to eat the food in a context where they naturally would consume it. Most consumers reported to consume the product at home, 79.2%, a considerable part at the job or school 14%, a minor part on-the-go 5.3%, 0.4% at a social arrangement and 1.1 % in another context (e.g. sport facility). Results showed no effect of where the consumers eat the products on ratings of SS, and FS immediately after intake and one hour after intake.

Meiselman et al (2000) argued that one of the most powerful influences of eating environment on food acceptance is expectations to the food in addition to the actual food properties. Cardello and colleagues have investigated expected liking of foods served in different settings (A. V. Cardello,

Bell, & Kramer, 1996). They found ranking of location according to expected liking to be: home > full service restaurant > diner/fast food > school foodservice > military foodservice > airline food service = hospital foodservice. Even though expected liking was not rated in the majority of the studies referred to in this section of the thesis, the ranking; harmonise the results on liking found in the two studies conducted by Meiselman et al (2000) and the study by Kennedy et al (2004), partly support the hedonic findings by King et al (2004) and contradicts to findings on FS conducted in relation to this thesis.

The relation between eating environment, expectations and satisfaction was mentioned by consumers participating in S1. Participants agreed that different locations gave rise to different expectations which could alter food satisfaction. Quote to illustrate the finding:

”expectations mean a lot, together with the surroundings where you eat. You don’t expect the same if you are outdoors in nature. A sandwich can be fine here. And it’s so practical. But if you visit friends that you know make good food, then you expect them to make something delicious and well prepared.”

Further expected liking was measured in the two contexts in S3, lab (*S3a*) versus natural context (*S3b*). When comparing expected liking ratings conducted in *S3a* and *S3b* a significant difference was found ($p < .01$), with the consumers participating in the laboratory test on average rating expected liking 0.45 point higher on the 9 point scale. Hereby, the ranking of expected liking in the two locations match the ranking of FS. The fact that expected liking was rated higher in the laboratory compared to the natural context seem to contradict the results found by Cardello et al (1996), though the two studies are not directly comparable, as the locations differed in the studies. One possible explanation for the different expectation ratings in *S3a* and *S3b* is the general more positive attitude characterising the consumers in *S3a* compared to consumers participating in *S3b*. When focusing on *S3b* only, no effect of test location (home versus job/school versus on-the-go versus social arrangement versus other) was found on expected liking. It can be argued that consumers’ expectations about pre-prepared products, as those used in S3, might not differ in the same extent as expectations to products being prepared at the location, and that this can explain why context effect only are found for some products/studies. But it cannot explain the differences between test locations found in S3.

Important to keep in mind, when comparing results from studies investigating the effect of physical location is that when changing the location for where to conduct the test, often not only the location changes, but the environments differ on a large number of variables. As the mixed results also imply, the influence of individual variables (or probably interactions among them) beside the physical location could have caused these differences. De Graaf and colleagues have summarised a list of potential differences between data collected in the laboratory as opposed to data collected in more realistic situation (de Graaf et al., 2005). Some of the relevant elements include: physical eating environment, food presentation and social eating context.

5.4.2 Social effects

Eating is a social matter, and the majority of meals are consumed in the company of someone else (H. Meiselman et al., 2006). Surveys conducted in the Nordic countries show that most respondents

eat alone for breakfast, alone or with colleagues at lunch, with family member for dinner and with others (family and friends) during the weekends (Kjaernes U., 2002). Other people can affect a subjects behaviour in different ways: by their presence, by the attention paid to the individual and his/hers activities and through persuasion or communication (Rozin & Tuorila, 1993). Previous research on social effects have focused on: number of people during a meal in relation to intake (de Castro, Brewer, Elmore, & Orozco, 1990; de Castro, 1994), eating duration and group size on intake (Pliner et al 2004), negative and positive communication in relation to food selection (J.S.A. Edwards & Meiselman, 2005). Surprisingly little research have focused on the effect of social context on hedonic ratings of foods.

Brown and colleagues (2013) conducted a qualitative study focusing on the hedonic impression of the whole eating experience, and not only the food. They found that participants expressed eating as a social act, and there was consensus that being in the company of others enhanced the eating experience and the feeling of satisfaction (Brown, Edwards, & Hartwell, 2013). Focusing on the hedonic experience of food, consumers participating in *SI* implied that the social context could alter the hedonic appreciation of foods. Quote from a consumer to illustrate the finding:

”Company is important. If the company is good then the food tastes better.” (*PI*)

To my knowledge, only King et al (2004) and Edwards et al (2013) have investigated the effect of social company on hedonic food appreciation quantitatively (2004). King and colleagues found that eating with others had a strong negative effect on hedonic ratings of pizza and neutral effects on salad and tea. They suggested that the negative effect on pizza might be caused by participants feeling uncomfortable eating hand held food in the presence of other people, some of them strangers (King et al., 2004). No influence of social context, eating alone or with others, was found on meal acceptability in the study conducted by Edwards and colleagues (2013).

In *S3b* the effect of social context on FS was studied. In *S3b* 55.1% of the participants reported to consumed the yoghurt w/muesli alone, 35% with family, 7.6% with colleagues and 2.3% with friends. A significant difference between “who consumers eat yoghurt w/muesli products with” (alone, family, colleagues or friends) was found on ratings of SS, and FS after- and one hour after intake. In general the lowest SS and FS ratings were found when consumers eat the products alone, and the highest when eating the products among others. An exception was eating with family which tended to affect SS and FS negatively. One possible explanation for the contradicting results could be the quality of the social company e.g. negative versus positive communication. It is possible that a positive communication could heighten the hedonic food experience, as was seen for selection rate in the study by Edwards and Meiselman (2005). But these effects were not studied in the respective studies conducted in relation to the PhD project.

5.4.3 Appropriateness

Appropriateness has been suggested as a general measure that describes how well a food is accepted for a certain use context (Schutz 1994). Several studies have found that appropriateness of specific foods changed, as the context changed e.g. this have been found for: vanilla ice cream (Lähteenmäki & Tuorila, 1995) and, juices, milk and chocolate milk (Lahteenmaki & Tuorila,

1997). Cultural rules seem to exist that affect how much people prefer to eat a particular food at a given context. As suggested by Birch et al (1984) early exposure to these cultural practices may associatively condition momentary preferences for specific food items at different meals. Although liking and appropriateness often are highly correlated, and highly liked foods find appropriate uses in a variety of situations, inappropriate contexts for a given culture may override influences of sensory liking (Lahteenmaki & Tuorila, 1997).

Appropriateness is often measured relating a food to a usage statement. These usage statements can be defined by; time of day, specific meals, gender, mood or a specific situation (Lawless & Heymann, 2010). Focusing on the usage statements; time and meals, cultural rules seem to exist that affect how much people prefer to eat a particular food at a particular time of day (Birch, 1984; Kramer, Rock, & Engell, 1992). In a field study liking for orange juices was rated differently when served as a part of a breakfast, lunch or dinner (Peryam & Gutman, 1958). However, in this study appropriateness was not measured explicitly. Studies using appropriateness more explicitly were conducted by Kramer et al (1992) and Schutz et al (1996). In the study by Kramer and colleagues hedonic ratings of breakfast- and lunch-foods were examined when served at appropriate and inappropriate times (Kramer et al., 1992). They found no effect of appropriateness or inappropriateness on hedonic ratings of food, and suggested that appropriateness may be more relevant to food selection than to palatability *per se*. These results are supported by Schutz et al (1996) who found that products differed in appropriateness, but appropriateness did not affect preference.

Appropriateness was measured in study *S2*, *S3a* and *S3b* by asking consumers to rate appropriateness of the food, by relating it to the time of consumption. In *S2* consumers were recruited to participate (and thereby eat soups) around lunch time or around dinner time. In *S3a* consumers participated with one-hour intervals throughout the day. And, in *S3b* yoghurts w/muesli were eaten for breakfast, lunch, early dinner, late dinner or snack. Ratings were conducted on a 9 point scale. The effect of appropriateness across products on SS and FS was analysed by mixed models grouping consumers in three groups; low appropriateness (rating 1-3), medium appropriateness (rating 4-6) and high appropriateness (rating 7-9). Consumers were regarded random effect and appropriateness-group as fixed effect. Results from *S2* showed that soups were found more appropriate around dinner time than around lunch time ($p < .0001$), but no effect of appropriateness-group was found on SS and FS ratings. In *S3b* yoghurts w/muesli differed significantly in how appropriate they were at the respective meals ($p < .003$). Yoghurt w/muesli were most appropriate for breakfast, lunch or a snack and least appropriate as an early dinner. Appropriateness ratings of consuming yoghurts w/muesli as a late dinner were in-between. Like in *S2*, no effect of appropriateness-group was found on SS and FS in *S3a* and *S3b*. Hereby our results support the findings of Kramer et al (1992) and Schutz et al (1996).

CHAPTER 6: SENSORY SATISFACTION VS. OVERALL LIKING

Of the two satisfaction terms (SS and FS), SS resemble overall liking the most. In the studies conducted in relation to this thesis, they are both regarded hedonic responses based on evaluation of the sensory experience. Further, they are measured during intake and are rated on a 9-point scale. However, though both terms focus on the hedonic experience of the sensory properties, and SS often is highly correlated with liking (unpublished results), they are believed to represent two different hedonic constructs. Attempt done, in the PhD project, to distinguish the two terms are discussed in this section. Generally, satisfaction is assumed to be somewhat more related to performance relative to expectations than liking is (Lawless & Heymann, 2010).

Several perspectives can be taken when elaborating on how “SS” and “overall liking” differ. In S4a, *PVI* the difference between the two terms were studied by focusing on, if the relation between “overall liking” and “liking of sensory properties” differed from the relation between “SS” and “liking of sensory properties”. It was hypothesised that consumers paid more attention to all four properties; appearance, odour, taste and texture when rating SS than when rating overall liking, as in SS consumers are guided to consider all four properties. If the consumer paid equal attention to all four properties, the relative relation between each of the property liking and SS would be 25%. For further methodological details see *PV*. Previous studies have shown that consumers primarily paid attention to taste when evaluating overall liking (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz & Krieger, 1995). Note, that in these studies overall liking was related to liking of: appearance, taste and texture. Liking of odour was not (and a comparison to sensory satisfaction was not done). In S4a, *PVI* liking of taste was likewise found to be the property consumer primarily paid attention to, both when evaluating overall liking and SS, as liking of taste was significantly higher related to overall liking and SS, than liking of any of the other properties were. Further, no difference was found in the relation between liking of any of the sensory properties and overall liking and SS, respectively, indicating that the two terms could not be characterised different when focusing on relation to liking of sensory properties.

PVI present another approach to study potential differences between overall liking and SS. The results are from S4b. It was studied if differences in: drinkability, drinking pleasure and liking of: taste, texture and aftertaste, were reflected in the measures of overall liking and SS, respectively. After intake of four fruit drinks, A, B, D and S (for description of products see *PVI*), consumers rated the variables: overall liking, drinkability, drinking pleasure, liking of: taste, texture and aftertaste and SS. Results showed that the fibre-rich fruit drink D was rated significantly lower in drinkability, drinking pleasure (not significantly different from B) and liking of texture compared to A, B and S. For liking of aftertaste drink B and D (D not significantly different from A and S) received lower ratings than A and S. No product effect was found for liking of taste. Overall liking was not rated different between products, but for SS fruit drink D was rated significantly lower than A and S, fruit drink B was intermediate. These results illustrate that differences in hedonic product perception was better reflected in the measure of SS than in the measure of overall liking. Further, the results indicated that consumers primarily paid attention to liking of taste when evaluating

overall liking, whereas several sensory experiences is included in the measure of SS. Together these results showed SS as a more discriminating measure than overall liking.

From a practical point of view, the two terms can be argued to differ based on where the questions are placed in the questionnaire, irrespectively of whether the focus is on satisfaction or liking. Previous studies have shown that the variables rated prior can affect ratings of the following response variables. This phenomenon is known as halo effect, when a positive product characteristic is carried-over to another unrelated product characteristic (Lawlees & Heymann, 2010), and have among other been demonstrated by Clark and Lawless (Clark & Lawless, 1994). The phenomenon is known as horn effect, when negative characteristics are carried-over to another unrelated product characteristics. Due to the risk of halos and horns it is generally recommended to ask the more generalized question about overall liking before questions about attribute liking (Lawlees & Heymann, 2010). In the questionnaires (appendix 1) consumers rated overall liking first, followed by liking of sensory properties and SS afterwards. As a consequence the question of SS is in greater risk of being biased from halos and horns than the question of overall liking. To avoid potential effects of position in the questionnaire, the position of questions about “overall liking” and “SS” could have been randomised. However, in a study conducted recently the position of the overall liking question did not have an impact on the overall liking score (de Bouillé & Worch, 2014). Important to mention here is the fact that SS is supposed to make consumers reflect upon liking of sensory properties, whereas the focus when rating overall liking is undefined for the consumer. For this reason overall liking was rated first as commonly advised (Lawlees & Heymann, 2010), and SS last, but the ratings could/should be affected by position in the questionnaire.

CHAPTER 7: CONCLUSION

This PhD project focused on increasing our knowledge about satisfaction and determinants to satisfaction in specific case studies. The conclusions on the two hypotheses that the PhD was based on are listed below.

The first hypothesis was that **food satisfaction can be used as a holistic response to consumers' hedonic appreciation of foods**. Two sub-aims were: to establish a theoretical understanding of the satisfaction term and to develop a working definition of satisfaction to be used prospectively in the PhD project.

Previous definitions of “satisfaction” were analysed to clarify common elements in the term. Definitions used within sensory science illustrated satisfaction as an affective summary response with focus on the food item. Which sensations the response was based on, and the timing of the response differed between definitions. The understanding of satisfaction was approached from an angle focusing on: the type of response, the focus of the response and the timing of the response. This approach was useful when developing a method to measure satisfaction and factors influencing satisfaction. A physiological and neurological understanding of the processes creating satisfaction was not included when establishing an understanding of the term, but would be relevant for a more complete understanding.

Two working definitions were created (section 2.2); one focusing on the sensory experience during intake, “sensory satisfaction”, and one focusing on the food in its context after perceiving sensations related to the sensory experience and physical- and psychological well-being, “food satisfaction”. Regarded as such, “food satisfaction” emphasised product performance and how well the food succeeded in creating a feeling of well-being appropriate for the specific context. Thereby our measure of food satisfaction assumes that foods are eaten or at least tasted. Some factors are not included in the definition. For instance factors important for “food choice” are out of scope of this definition, but in reality these factors can be of major importance for consumer satisfaction. One example is “religion”, and how religion related beliefs and values effect our perception and hedonic appreciation of foods. If such factors should have been included, a broader definition should have been conducted.

Taking the two sub-aims into account, the work on the understanding and definition of satisfaction suggest that satisfaction can be used as a holistic response to hedonic food appreciation.

The second hypothesis was that **satisfaction with foods is multi-dimensional and the sensory experience as well as other product related factors, person- and situational factors contribute to satisfaction**. Sub-aims were: to develop a vocabulary of factors potentially affecting satisfaction, to develop a method measuring satisfaction and use it to measure satisfaction in case studies, and to explore the influence of product-, person- and context related factors in satisfaction in concrete product cases.

A dictionary definition of “vocabulary” describe the term as “a body of words used in a particular language”. Understood in relation to satisfaction, a vocabulary could refer to “the body of words used to describe satisfaction”. However, in the present PhD project “vocabulary” was used when

referring to the response variables measured during the study of factors influencing satisfaction. Thereby the vocabulary included factors which had the potential to affect satisfaction, and not only those that were found to affect satisfaction. The decision on which factors to measure was based on a) findings from a focus group study conducted in relation to the PhD project, where factors affecting satisfaction were described and discussed by consumers, b) considerations on the definition, c) a model developed by Mojet focusing on factors important for food choice and behaviour and d) considerations on the processes with a potential to affect satisfaction. Work on the vocabulary brought light to a temporal perspective, where different factors were suggested important for satisfaction at different time points relative to intake. The factors were not only related to the product, but also the person consuming the product, and the context the product was consumed in. The factors were classified into “product related”-, “person related”-, “product-person inter-related”- and “context related”- factors.

In the wish for studying how factors from several of these classifications affected satisfaction, a set of questionnaires were developed. The questionnaires were to be filled out by consumers before-, during- and after intake. Response variables included sensory- and food satisfaction as well as factors from each classification. The questionnaires were developed, so that they could be applied on a broad range of products and reveal information on degree of sensory- and food satisfaction, and on factors influencing satisfaction. The basic set of questionnaires was used in a study involving two different versions of a creamy chicken soup (S2, *PII*). A slightly modified version, including measures one hour post intake, was applied in two studies on yoghurt w/muesli products (S3a and S3b, *PIII* and *PIV*). And finally, a version targeted selected fruit drinks, was applied, which mainly focused on physical sensations post intake (S4a and b, *PV* and *PVI*). Results showed that several factors within the classifications: “product-person inter-related”-, “person related”- and “context related” factors influenced food satisfaction. These determinants are summarised in Table 1. “Product related” factors were investigated in relation to “sensory satisfaction” and specific attributes were found influential in “sensory satisfaction” in the respective studies.

In the studies conducted in relation to the present thesis, the primary focus was on increasing our understanding of satisfaction and not on the products as such. The focus would of course be different if the method was applied by the industry. For future use, the questionnaires could by advantage be targeted the product of interest, so that focus would be on factors the industry finds important for satisfaction with the specific food.

Related to hypothesis two, it can be concluded that satisfaction with food seems multi-dimensional, and factors related to the product, person and situation all contribute to satisfaction. Despite the many factors included in the respective studies, these do not account for all the variation in food satisfaction. This indicates that there are factors important for a feeling of food satisfaction which has not been approached in the respective studies. However, it is still evident that the studies conducted in relation to this PhD project make a remarkable contribution to our understanding of sensory- and food satisfaction; how the satisfaction terms can be distinguished, and which factors that influence consumers’ ratings of “sensory satisfaction” and “food satisfaction”. In order to be able to generalise the results, more research is needed, focusing on a broader range of product within the respective food categories and across other food categories.

CHAPTER 8: PERSPECTIVES

The knowledge acquired in the present PhD project holds many applications; it has opened up for future research focusing on the satisfaction construct and determinants to satisfaction, and suggested a method which can be used by the industry as a holistic approach to consumer satisfaction. Below are suggestions to how the results can be applied and suggestions to future research within satisfaction.

The overall idea behind the SENSWELL project was to investigate determinants to food satisfaction, and use the knowledge as a strategy to promote healthy and sustainable eating practice. The findings from the present PhD project show that SS is highly influential in FS. Therefore, the industry should continue to develop products which not only have health beneficial properties but also fulfil (or even exceed) consumers expectations and desires for sensory quality. Findings from the present PhD project further show that SS are not the only factors influencing FS. Sensations related to physical wellbeing post intake influence satisfaction as well. With special attention to fibre addition, consumers reacted positively towards increased feelings of fullness, but the sensory consequences and physical sensation following intake e.g. nausea needs to be improved for consumers to be satisfied.

However, important for the application of “satisfaction” as a strategy to promote healthy eating practices, is to study, how satisfaction relates to amount of food consumed. Do FS unconditional result in increased intake? Or, can satisfaction result in decreased intake, if consumers experience e.g. a more complete sensory experience? Future research could focus on investigating sensory strategies to reduce energy intake without compromising satisfaction. In this regard, the role of tactile compounds in SS needs research, as well as whether addition of spices could serve as a strategy to decrease energy intake without compromising satisfaction.

A limited amount of research has focused on the effect of social context on food appreciation. In the light of SENSWELL more research is needed focusing on, how the social context can be used to gain higher satisfaction from healthy foods. E.g. the study of how communication and quality of communication during a meal affect hedonic food appreciation.

The set of questionnaires which were developed in relation to the present PhD project holds potential for future use within the food industry. Instead of focusing on single response variables related to e.g.: the sensory experience, physical sensations after intake or the context surrounding consumption, the questionnaires were based on a holistic approach, where several of these variables were included. Future work on the questionnaires is advised to keep the holistic approach to satisfaction, but increase application through development of questionnaires targeted specific food categories. Depending on the product category in focus, the method could therefore be refined; keeping some response variables while leaving others out. For example, it could be hypothesised that industries working with sweets would be more interested in response variables discriminating sensations related to hedonic hunger, moods and the eating context, than to e.g. homeostatic hunger.

Finally, it would be interesting to study if consumers interpret the questions about “sensory satisfaction” and “food satisfaction” as intended. When using the questions in the respective

questionnaires, it was assumed that the questions were interpreted as described in the definitions. However, consumers were not presented with the definitions, and therefore the interpretation was unknown. To clarify how consumers interpreted the questions about “sensory satisfaction” and “food satisfaction”, and which cognitive comparisons they made, personal interviews could be conducted after the test. Personal interviews could also reveal if consumers evaluated the questions as explicit as but here, or if the question were filled out more spontaneous without explicit cognitive involvement.

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APPENDIX 1: QUESTIONNAIRES

Questionnaire for study 2

Questionnaire for study 3

Questionnaire for study 4

Questionnaire S2
(Pre intake)

Welcome,

You will receive a total of three questionnaires which are to be answered; before-, during- and after intake of a creamy chicken soup. Below is the first questionnaire. For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, but **do only make one mark for each question unless indicated differently**. Answers are treated confidentially and only in connection to the project. You will stay anonymous in all cases.

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel your stomach is full?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well physically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well psychologically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel energetic?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you expect to like the food?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you think the food can fulfil your expectations?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like the eating soup?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel the food is appropriate to eat the soup at this time of day?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

In case you have further remarks please make a note below

Questionnaire

(Peri intake)

Please eat the amount of soup you feel like and answer the questionnaire concurrently. If you have finished your soup and feel like more, please call a project employee.

For each question please mark the answer that corresponds the way you feel right now.

Please answer all questions, but **do only make one mark for each question unless indicated differently.**

How much do you like the soup?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

If you only consider the appearance, how much do you like the soups appearance?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the soups odour?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the soups taste?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Do you perceive an aftertaste?

- No → answer question X next
- Yes

How will you describe the aftertaste?

- Unpleasant. Describe: _____
- Pleasant

How much do you like the soups texture?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

If you consider the appearance, odour, taste and texture all together, how satisfied do you then feel?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

In case you have further remarks please make a note below

Questionnaire
(after intake)

For each question please mark the answer that corresponds the way you feel right now. Please answer all questions in the order they appear in the questionnaire. **Do only make one mark for each question unless indicated differently.**

Why did you finish your meal?

- I was satiated
- The food bored me
- The food felt unpleasant
- My conscious told me not to continue eating
- Other reason. Describe: _____

How satisfied are you with the soup right now?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

Do you feel your expectations are fulfilled?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

If you compare your expectations and your experience eating the soup, was the experience then..

- Worse than expected
- As expected
- Better than expected

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel your stomach full?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like having anything else to eat or drink right now?

- No
- Yes, but don't know what
- Yes. Describe: _____

Do you feel well physically?

- No
- Yes

Do you feel like eating the food again in the future?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

If you compare how physically well you felt before the meal and how physically well you feel now. Do you then feel...

- Decreased physical well-being
- The same level of physical well-being
- Increased physically well-being

If you compare how psychological well you felt before the meal and how psychological well you feel now. Do you then feel...

- Decreased psychological well-being
- The same level of psychological well-being
- Increased psychological well-being

In case you have further remarks please make a note below

For each question please mark the answer corresponding to how you generally think about yourself. For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, and **do only make one mark for each question unless indicated differently.**

Do you consider yourself a person who likes almost all foods?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you like to taste food you have not tasted before?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you often feel like having anything else to eat or drink after a meal?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

How often do you eat soup?

- ≥ once per week
- 2-3 times per month
- once per month
- 1-5 times per half year
- < once per half year

Do you feel like having soup more often?

- Yes
- No, it is appropriate
- No, it is too often
- Don't know

In general, how much do you like soup?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Name:	Date:
Address:	Zip-code and city:
Country:	Phone number:
Height (cm):	Weight:
Birthday and year:	

Gender

- Male
- Female

Number of persons in your household (incl. you)? _____

Number of adults aged 18 years or older _____ (incl. you)

Number of children below 18 years _____

Completed education (the latter of your educations) (only t=40)

- Lower secondary
- Upper secondary
- Upper secondary with trainee
- Short length higher education (≤ 2 years)
- Medium length higher education (2 – 4 years)
- Long higher education (>4)
- Other: _____

Household income last year (before tax) (only t=40)

- < 100.000 DK kr.
- 100.000 – 199.999 DK kr.
- 200.000 – 299.999 DK kr.
- 300.000 – 399.999 DK kr.
- 400.000 – 599.999 DK kr.
- 600.000 – 799.999 DK kr.
- > 800.000 DK kr.
- Do not wish to state

Would you like to participate in a consumer test again?

- Yes, please contact me
- No

In case you have further remarks please make a note below

Thanks for participating!

Questionnaire S3
(Pre intake)

Welcome,

You will receive a total of three questionnaires which are to be answered; before-, during- and after intake of a yoghurt w/muesli.
For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, but **do only make one mark for each question unless indicated differently**. Answers are treated confidentially and only in connection to the project. You will stay anonymous in all cases.

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel your stomach is full?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well physically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well psychologically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you expect to like the yoghurt w/muesli?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you think the yoghurt w/muesli can fulfil your expectations?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like the eating yoghurt w/muesli now?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel it is appropriate to eat yoghurt w/muesli at this time of day?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

In case you have further remarks please make a note below

Questionnaire

(Peri intake)

Please eat the amount of yoghurt w/muesli you feel like and answer the questionnaire concurrently. If you have finished your portion and feel like having more, please call a project employee.
For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, but **do only make one mark for each question unless indicated differently.**

How much do you like the yoghurt w/muesli?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

If you only consider the appearance, how much do you like the yoghurt w/muesli's appearance?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the yoghurt w/muesli's odour?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the yoghurt w/muesli's taste?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the yoghurt w/muesli's texture?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

If you consider the appearance, odour, taste and texture all together, how satisfied do you then feel?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

In case you have further remarks please make a note below

Questionnaire
(Post intake)

For each question please mark the answer that corresponds the way you feel right now. Please answer all questions in the order they appear in the questionnaire. **Do only make one mark for each question unless indicated differently.**

Do you perceive an aftertaste?

- No → answer question X next
- Yes

How much do you like the aftertaste?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Why did you finish your meal?

- I was satiated
- The food bored me
- The food felt unpleasant
- My conscious told me not to continue eating
- Other reason. Describe: _____

How satisfied are you with the yoghurt w/muesli right now?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

Do you feel your expectations are fulfilled?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

If you compare your expectations and your experience eating the soup, was the experience then..

- Worse than expected
- As expected
- Better than expected

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel your stomach full?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like having anything else to eat or drink right now?

- No
- Yes, but don't know what
- Yes. Describe: _____

Do you feel like eating the yoghurt w/muesli again in the future?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well physically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well psychologically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

In case you have further remarks please make a note below

For each question please mark the answer corresponding to how you generally think about yourself. For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, and **do only make one mark for each question unless indicated differently.**

How often do you eat yoghurt w/muesli?

- ≥ Once per week
- 2-3 times per month
- Once per month
- 1-5 times per half year
- < Once per half year

Do you feel like having yoghurt w/muesli more often?

- Yes
- No, it is appropriate
- No, it is too often
- Don't know

In general, how much do you like yoghurt w/muesli?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Do you consider yourself a person who likes almost all foods?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you like to taste food you have not tasted before?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you often feel like having anything else to eat or drink after a meal?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

If yes, please name max. 3 foods: _____

For which meal did you eat the yoghurt w/muesli? (Only for S3b)

- Breakfast
- Lunch
- Early dinner
- Late dinner
- Snack

Where did you eat the yoghurt w/muesli? (Only for S3b)

- Home
- Work/school
- Social arrangement
- One-the-go
- Other. Description: _____

Who did you eat the yoghurt w/muesli with? (Only for S3b)

- Alone
- Family
- Colleagues
- Friends
- Others. Description: _____

Before you eat the yoghurt w/muesli, when did you then eat? (Only for S3b)

- The day before
- > 2 hours before
- 1-2 hours before
- < one hour before

Which meal did you eat before the yoghurt w/muesli meal? (Only for S3b)

- Breakfast
- Lunch
- Early dinner
- Late dinner
- Snack

Gender

- Male
- Female

Your height (only t=40) _____ (cm)

Your weight (only t=40) _____ (kg)

Number of persons in your household (incl. you)? _____

Number of adults aged 18 years or older _____ (incl. you)

Number of children below 18 years _____

Completed education (the latter of your educations) (only t=40)

- Lower secondary
- Upper secondary
- Upper secondary with trainee
- Short length higher education (≤ 2 years)
- Medium length higher education (2 – 4 years)
- Long higher education (>4)
- Other: _____

Household income last year (before tax) (only t=40)

- < 111.000 N kr.
- 111.000 – 221.999 N kr.
- 222.000 – 332.999 N kr.
- 333.000 – 443.999 N kr.
- 444.000 – 665.999 N kr.
- 666.000 – 887.999 N kr.
- > 888.000 N kr.
- Do not wish to state

In case you have further remarks please make a note below

Questionnaire
(One hour post intake)

If you think back on the yoghurt w/muesli's appearance, odour, taste and texture, how satisfied were you then?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

If no, please answer question X next

When did you started to feel hungry?

- I was never satiated
- < 30 minutes after intake
- 30 – 60 minutes after intake

In the time span from after intake and until now, did you experience pleasant stomach feelings?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

In the time span from after intake and until now, did you experience pleasant energy level?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like having anything else to eat or drink right now?

- No
- Yes, but don't know what
- Yes. Describe _____

How satisfied are you about the yoghurt w/muesli right now?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

In case you have further remarks please make a note below

Questionnaire for S4a

You will receive four taste samples of apple-cherry fruit drink which you must drink and rate one at the time. First you will answer about the half of the questionnaire, then drink the taste sample and answer the rest of the questionnaire. **You must drink and rate the samples in the order written in the questionnaire.**

For each question please mark the answer that corresponds the way you feel right now. Please answer all questions, but **do only make one mark for each question unless indicated differently.** Answers are treated confidentially and only in connection to the project. You will stay anonymous in all cases.

Before drinking the fruit drink no. X, please answer the questions below

Do you expect to like the fruit drink?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you think the fruit drink can fulfil your expectations?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like drinking the fruit drink right now?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

When you only consider the fruit drinks' appearance, how much do you like the appearance?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the fruit drinks' odour?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

Now drink all of no X and answer the rest of the questionnaire concurrent

How much do you like the fruit drink?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the fruit drinks' taste?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

How much do you like the fruit drinks' texture?

Dislike extremely	Dislike very much	Dislike moderately	Dislike slightly	Neither like nor dislike	Like slightly	Like moderately	Like very much	Like extremely

If you consider the appearance, odour, taste and texture all together, how satisfied do you then feel?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

When comparing your expectations and your actual experience drinking the fruit drink, the beverage was..

- Worse than expected
- As expected
- Better than expected

In case you have further remarks please make a note below

Repeated for the four fruit drinks!

Questionnaire S4b

(Pre intake)

There are now 15 minutes wait. Please stay seated, answer this questionnaire and feel free to use the crossword puzzle at your seat.

Are you hungry?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Are you thirsty?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel your stomach is full?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel nausea?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel reflux?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel energetic?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well physically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well psychically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

In case you have further remarks please make a note below

You will receive a fruit drink and after approximately 2 minutes a questionnaire. For each question please mark the answer that corresponds the way you feel right now. **Allow yourself a moment to take special notice in how you feel right now.** Please answer all questions, but do only make one mark for each question unless indicated differently. Following, with 10-minute intervals you will receive a new questionnaire. Even though you might experience wait please stay seated and if you feel like it, please use the crossword puzzle at your seat.

Please drink the whole fruit drink during the next two minutes. Following you will receive the next questionnaire

Do you feel reflux?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel energetic?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well physically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel well psychologically?

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you feel like having anything else to eat or drink?

- No
- Yes, but I do not know what
- Yes. Clarification: _____

Do you feel the fruit drink could replace a snack? (only t= immediately and 40)

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

How satisfied are you about the fruit drink right now?

Extremely unsatisfied	Very much unsatisfied	Moderately unsatisfied	Slightly unsatisfied	Neither satisfied nor unsatisfied	Slightly satisfied	Moderately satisfied	Very much satisfied	Extremely satisfied

How often do you normally drink fruit drinks? (only t=40)

- 3 times a week or more
- 1-2 times a week
- 2-3 times a month
- Once a month or less

When do you drink fruit drinks? (only t=40)

- For breakfast, lunch and/or dinner
- As a snack
- At a special occasions. Note an example _____

Do you consider yourself a person who likes almost everything? (only t=40)

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Do you like to taste foods you have not tasted before? (only t=40)

No, extremely not	No, very much not	No, moderately not	No, slightly not	Neither yes nor no	Yes, slightly	Yes, moderately	Yes, very much	Yes, extremely

Gender (only t=40)

- Male
- Female

Your height (only t=40) _____ (cm)

Your weight (only t=40) _____ (kg)

Number of persons in your household (incl. you)? (only t=40) _____

Number of adults aged 18 years or older _____ (incl. you)

Number of children below 18 years _____

Completed education (the latter of your educations) (only t=40)

- Lower secondary
- Upper secondary
- Upper secondary with trainee
- Short length higher education (≤ 2 years)
- Medium length higher education (2 – 4 years)
- Long higher education (>4)
- Other: _____

Household income last year (before tax)

- < 100.000 DK kr.
- 100.000 – 199.999 DK kr.
- 200.000 – 299.999 DK kr.
- 300.000 – 399.999 DK kr.
- 400.000 – 599.999 DK kr.
- 600.000 – 799.999 DK kr.
- > 800.000 DK kr.
- Do not wish to state

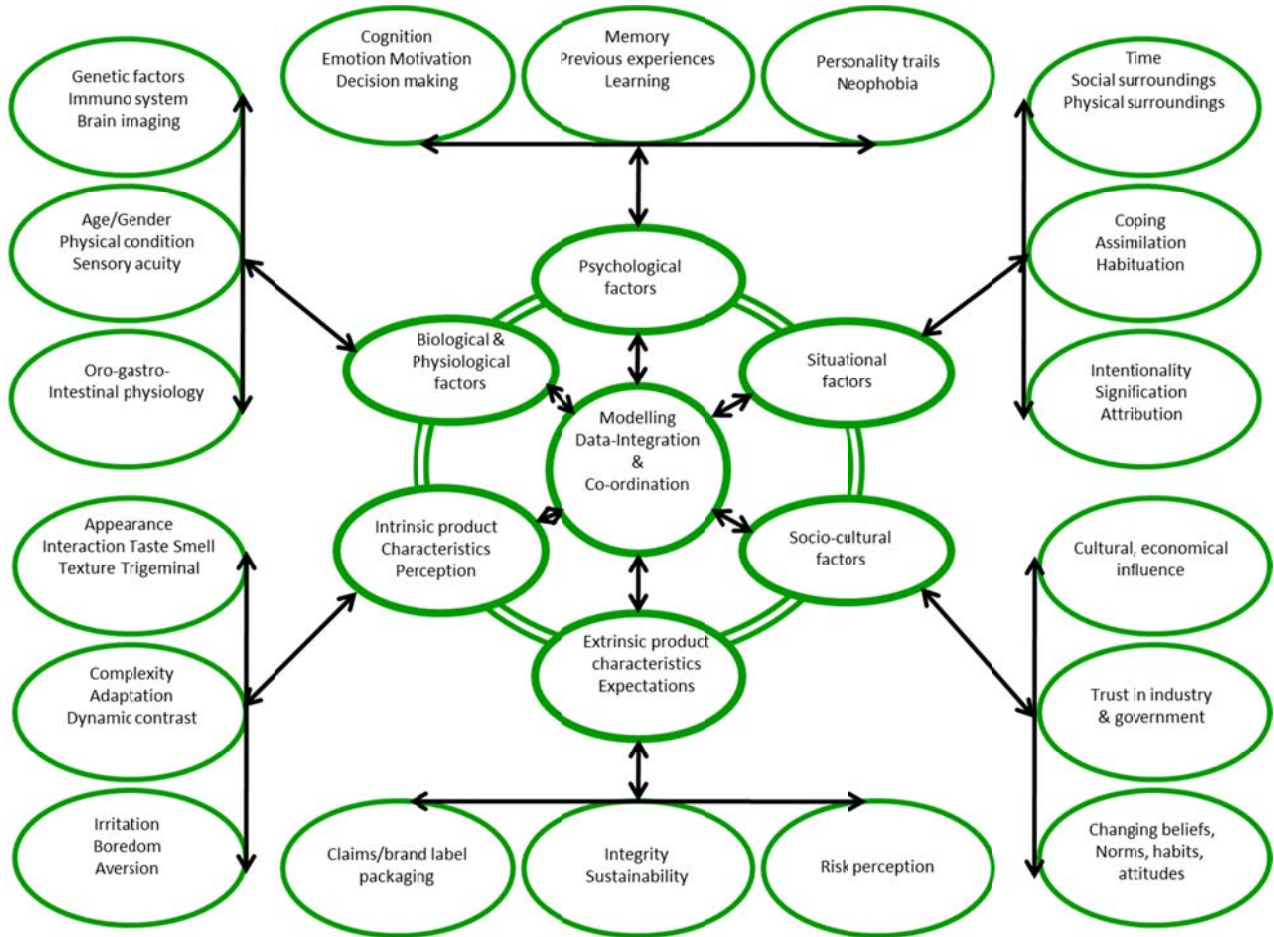
Would you like to participate in a consumer test again?

- Yes, please contact me
- No

In case you have further remarks please make a note below

Thanks for participating!

APPENDIX 2: MODEL OF FACTORS AFFECTING FOOD CHOICE AND BEHAVIOUR



Model of factors affecting food choice and behavior, developed by Jos Mojet (E. P. Köster, 2009)
Shown with permission from Jos Mojet.

APPENDIX 3: PAPERS

Paper I: Consumers' view on determinants to food satisfaction. A qualitative approach

Barbara Vad Andersen & Grethe Hyldig

Submitted to *Appetite*, September 2014

Paper II: Food satisfaction: Integrating feelings before, during and after food intake

Barbara Vad Andersen & Grethe Hyldig

Submitted to *Food Quality and preference*, September, 2014

Paper III: The effect of protein content and study context on consumers' rating of hunger, fullness and food satisfaction. A case study using yoghurt with muesli products.

Barbara Vad Andersen, Hilde Kraggerud, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

Paper IV: Peri- and post intake drivers of satisfaction with yoghurt with/muesli products

Barbara Vad Andersen, Hilde Kraggerud, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

Paper V: Factors important for sensory satisfaction and food satisfaction after intake of fruit drinks varying in sweetener and addition of aroma and fibres

Barbara Vad Andersen, Line Holler Mielby, Ida Viemose, Wender L.P. Bredie & Grethe Hyldig

Draft, to be submitted

Paper VI: The relation between liking of sensory properties and sensory satisfaction. A comparison to overall liking.

Barbara Vad Andersen, Per Bruun Brockhoff & Grethe Hyldig

Draft, to be submitted

PI

Consumers' view on determinants to food satisfaction. A qualitative approach

Barbara Vad Andersen^{a*} & Grethe Hyldig^a

^aNational Food Institute, Department of Industrial Food Research, DTU, Building 221, DK-2800 Kgs. Lyngby, Denmark

*Corresponding author. E-mail address: bvan@food.dtu.dk Phone: 0045 45252548.

Abstract

The objective of this study was to gain a better understanding of the multiple determinants to food satisfaction from a consumer perspective. The study includes two focus groups with a total of 20 consumers varying in gender, age, employment and food interest. The results were divided into sections based on the main themes that arose from analysing the focus groups; i) sensory properties, ii) physical wellbeing, iii) expectations and desires, iv) the food context and v) comparison of the importance of the various determinants to satisfaction. Factors important for food satisfaction appear before as well as during and after intake. Before intake expectations and desires based on memories about previous food experiences and the context in which the food is perceived is important. Physical wellbeing was mentioned important for the feeling of satisfaction, included in physical wellbeing is the experience of an appropriate energy level after intake. In general the sensory experience seems to be the primary determinant to satisfaction. The hedonic experience of eating could be enhanced by the social company and knowledge about the food incl. health value and origin.

Highlights

- Factors important for food satisfaction appear before as well as during and after intake.
- Before intake expectations and desires based on memories about previous food experiences and the context in which the food is perceived is important.
- Physical wellbeing was mentioned important for the feeling of satisfaction, included in physical wellbeing is the experience of an appropriate energy level after intake.
- The sensory experience seems to be the primary determinant to satisfaction.
- The hedonic experience of eating could be enhanced by the social company and knowledge about the food including health value and origin.

Introduction

The value of consumer food acceptance has long been recognized by the industry. In the aim of gaining product success, food scientists and product developers work on optimizing food appreciation by developing products that meet (or even surpass) consumers need and wishes. Appreciation of foods has been found to be affected by a broad range of factors. Among these are: palatability, postprandial wellness and the context in which the food is eaten. Palatability is related to the food sensory characteristics, and how food is perceived through the sense of vision, taste, hearing, sound and touch (e.g. Sørensen, Møller, Flint, Martens, & Raben, 2003). Along with perceiving food sensory characteristics a hedonic dimension is elicited (AV Cardello, 1997). Previous research recognises that the hedonic dimension can be altered by manipulating sensory characteristics e.g. perceived variety (e.g. MM Hetherington, 1996; B J Rolls, Van Duijvenvoorde, & Rolls, 1984; B. Rolls, 1981). Postprandial wellness covers both psychological and physical sensations. Food appreciation is believed to be affected by consumption through effects on psychological well-being sensations, such as changes in mood and relaxation (e.g. Patel, 2001; Rogers, Green & Edwards, 1994). Among the physical factors satiation, satiety, energy level and sleepiness have been associated to food appreciation (Boelsma, Brink, Stafleu, & Hendriks, 2010; Kringelbach, Stein, & van Harteveldt, 2012). Further, other studies have investigated the context surrounding consumption and found that intake and hedonic appreciation of food depend on the context in which the food was presented (H. L. Meiselman, Johnson, Reeve, & Crouch, 2000). However, common for many studies are, that they approach one of these dimensions when studying food appreciation. This strategy is beneficial when focusing on the effect of the single variables, but the complexity that embrace food appreciation in real life is lacking. Several researchers have implied a need to study food appreciation using an approach which acknowledges that multiple determinants exist (e.g. Boelsma, Brink, Stafleu, & Hendriks, 2010; A. V Cardello et al., 2000; H. Meiselman, 1992; Sørensen, Møller, Flint, Martens, & Raben, 2003). As a consequence Cardello and colleagues (2000) stressed that the measures we traditionally use must be expanded and suggested “satisfaction”, a measure normally used within marketing, as a relevant alternative. Cardello and colleagues hypothesised that satisfaction represented a general appreciation of the food within a broader context, and it could be used to imply the food’s value, its utility or its adequacy for the situation (Armand V Cardello et al., 2000). Within marketing “satisfaction” has been used to describe product performance, but also to describe consumers contentment with purchase-related aspects like evaluation of sales persons and a stores (Giese & Cote, 2000). Based on a review of 20 satisfaction definitions used within marketing, it was concluded that satisfaction could be regarded a summary affective response to a broad range of consumption issues (Giese & Cote, 2000).

These findings suggest “satisfaction” as a multidimensional concept that holds potential for use within sensory science. However, in order to be able to use “satisfaction” as a holistic response variable within sensory science, a better understanding of the term is needed, inclusive an understanding of the factors potentially affecting satisfaction. The present study was undertaken to study the complexity of “food satisfaction” by investigating determinants to satisfaction from a consumer perspective. In the longer term, the determinants to “food satisfaction” will be included in a quantitative study investigating factors influential in “food satisfaction” in specific case studies. In this regard, the consumer perspective in the present study is important, as it is ultimately the consumers who will rate satisfaction in sensory studies and response variables should harmonise with consumers’ meaning of satisfaction.

1. Methods

2.1 Participants

Two focus groups were conducted at the National Food Institute, The Danish Technical University, involving 20 Danish consumers in total. A recruitment procedure was used to screen participants. Inclusion criteria were: age range 18-69 years, normal food habits and not suffering from food allergies as well as employment and food interest. Participant characteristics can be seen in table 1. Participants received gifts consisting of wine or chocolate in return for their contribution.

Table 1. Characteristics for participants in focus groups

Characteristic	
N _{total}	20
Gender; males, females	9 males, 11 females
Age; mean (min, max)	46 (18, 69)
BMI; mean (min, max)	25 (17, 34)
Food interest ^a	5, 8, 7

^aSubjective claimed food interest; number of participant with low-, medium- and high food interest, respectively

2.2 Pre-test

Before conducting the focus group among consumers, a pre-test was conducted among employees not working with sensory and consumer research. The pre-test aimed to test the procedure. On the basis of the pre-test, the interview themes were refined.

2.3 Interview protocol

In the 90 minutes focus group sessions, participants were asked questions related to their experience of food satisfaction while eating and which factors they identify as important for the feeling of satisfaction. Project goals were explained prior to start, and assurances of anonymity and confidentiality were given. The focus group discussions followed a protocol based on a semi-structured interview guide. The interview guide consisted of an introduction and a list of topics that had to be discussed. An outline of the interview guide can be seen in table 2.

Table 2. Outline of interview guide

Section/task	Description
Introduction	Presentation of moderator and assistant. Introduction to the interview and practicalities.
Presentation of participants	Participants introduced themselves, their background, household and general interest in foods.
Selection of lunch meal	Participants were asked to select one of eight pictures of different lunch meals. The selected picture should correspond to the subjects most preferred lunch. The task was followed by a discussion of reasons for choosing the lunch meal.
Deselection of lunch meal	Participants were asked to deselect a picture of a lunch meal. The deselection should correspond to the subjects least preferred meal. The task was followed by a discussion of reason for deselection.
Association	Participants discussed their selection and deselection in relation to previous meal experiences (previous meal, yesterday's meal, childhood memories etc.)
Reflection on satisfaction	Discussion of factors important for the feeling of satisfaction
Closure	Additional comments, evaluation of interview, questionnaire about demographic data and gifts

To encourage participant to express their views and discuss contradicting views, the focus groups were organized around tasks and themes evolving from a concrete to a more abstract level. Consumers are used to talking about likes and dislikes of foods, but talking about satisfaction and determinants to satisfaction can be unfamiliar and a difficult task to accomplish. To ease the dialogue and abstract thinking, pictures of eight lunch meals were provided. The meals were prepared at the institute and the composition were chosen based on their differences, and ability to represent the "novel vs. tradition-bound", "Danish vs. foreign", "sensory complex vs. sensory uniform", "light vs. heavy meal". The pictures of the eight meals can be seen in figure 1.



Figure 1. Lunch meal pictures used in the focus groups

The interviews started by asking participant to select and deselect their most/least desired meal and reflect on their choices. The actual selection/deselection was not of direct interest, but was used as a strategy to make the consumers reflect upon why certain foods satisfy them and others don't. As the interview progressed the dialogue became more based on associations instead of the pictures allowing more generalized but also more abstract thinking. By the end of the focus group a questionnaire was handed out with questions about demographics.

Each group were moderated by the same interviewer to ensure consistency in interviewing style. Additional assistance was provided by a note taker. The focus groups were audio- and video recorded using the Noldus Media Recorder software version 2.0.

2.4 Material analysis

The interviews were analysed for themes and content. Prior to the actual analysis, summaries were conducted for each focus group by two researchers independently to obtain a coherent picture of what had been discussed in each group. The summaries made a foundation for a thematic analysis, and quotes were pulled to illustrate the themes. Specific quotes that focus on how consumers describe satisfaction were chosen for this paper.

2. Results

The results have been divided into sections based on the main themes that arose from analysing the focus groups; i) sensory properties, ii) physical wellbeing, iii) expectations and desires, iv) the food context and v) comparison of the importance of the various determinants to satisfaction. The quotes that have been chosen are the ones where the factors affecting food satisfaction are brought up.

The brackets clarify the context in which the quotes are made and are included to ease understanding of the quotes.

3.1 Sensory properties

The sensory food properties were mentioned by all participants as a key determinant to satisfaction. Appearance, taste (understood as flavour) and texture were the sensory properties primarily mentioned, and mostly in relation to subjective likes and dislikes.

”It’s the taste (that gives satisfaction), so it tastes good.”

”...colourful food. Love lots of colours. It should be green, red – the whole colour spectrum.”

”It has to have texture, something with texture in it.”

Several pointed out, that the food components making the meal and hereby the sensory experience, should not only match subjective preferences but the components included in a meal should vary in sensory characteristics, making the meal a varied, but balanced, sensory experience. However subjectivity was observed, as not all participants were comfortable with the idea of a varied meal

”(about dissatisfaction) There is nothing (ingredients/ food components) in the dish that I don’t like, but the combination results in a poor taste experience.”

”Taste is fairly important. It’s taste variation that’s mostly responsible for giving (the dish/food) palate.”

”Like that it isn’t mixed (ingredients/food components) but that they are separate.”

The sensory experience should not only vary within a meal but also between meals. It was mentioned, that foods sharing the same sensory profile as recently eaten foods were not chosen.

”If I had had that for lunch, then my craving for the same wouldn’t be very strong.”

”what you’ve had yesterday and the day before yesterday, you start there (and try to avoid it).”

3.2 Physical wellbeing

State of hunger was mentioned important for the feeling of satisfaction both before and after food intake. Before intake, participants focused at the importance of being hungry, as satiety could hinder satisfaction, by altering the hedonic impression of the sensory experience.

”there needs to be a long stretch with an empty stomach. Then there is a (sensory) experience. I can’t appreciate it, if I’ve just eaten something.”

After intake satisfaction was explained closely related to satiation and satiety.

”I wouldn’t be satisfied, if I went away hungry.”

”The whole point of eating is to be full, but preferably with different tastes.”

Though everyone finding satiation to be an important part of satisfaction some mentioned, what could be referred to as “pleased senses” and that fulfilment of a need for “pleased senses” works differently from satiation

”Being full isn’t a goal for me. I eat to taste.”

”it means something when you eat, that you get different textures and tastes. I don’t know if you feel fuller faster, but you are satisfied in a different way. I do, at least.”

Further, the feeling of having an appropriate energy level according to the activity to be executed after the meal was mentioned in relation to satisfaction.

“If you have to accomplish something afterwards, you would feel better (with choosing a lighter meal). That’s my experience.”

”It’s about not eating too much and not eating too heavy (a meal), because then you can just as well lie down and take a nap. You have to have a good feeling in your body. Neither too heavy nor get hungry again too soon.”

3.3 Expectations and desires

Desires and expectations prior to eating were pointed out important, as it was upon expectations and desires the consumers based their hedonic judgment. Expectations and desires were created by associations to previous food experiences and compared to the actual experience when eating the food.

“there is no doubt that expectations mean something. Because when you are going to a party or out to eat, then you expect more (than an ordinary day at home). If it’s an ordinary day at home, then I just need something I like and that fills me up. At festive occasions, I need a taste experience, something new.”

”expectations mean a lot, together with the surroundings where you eat. You don’t expect the same if you are outdoors in nature. A sandwich can be fine here. And it’s so practical. But if you visit friends that you know make good food, then you expect them to make something delicious and well prepared.”

Some participants felt satisfaction through experiencing a positive surprise and thereby in advance not to know exactly what to experience, whereas others were uncomfortable by not knowing what to experience.

”(dissatisfaction) I know how it will taste, I know how it will feel. There is no experience. I know how it (the experience) will be.”

”I’m not very good at trying something new because I don’t know what’s coming.”

3.4 The food context

The degree of pleasure consumers felt while and after eating depended on the context in which the food was eaten. The same food could be perceived hedonically different depending on the context and the time of the day.

”at lunch I eat to get full, but otherwise I eat to taste”

”I imagine that it’s an ordinary day that I would choose this (tuna salad). If it had been a weekend, then I would have chosen the platter.”

The social context could for some consumers alter the hedonic value of the food, while others pointed out, that for them it was a different kind of satisfaction, but also important for the hedonic meal experience.

”Company is important. If the company is good then the food tastes better.”

”it has a lot with your social surroundings. I can make a delicious meal for myself but it’s not the same eating it alone (in contrast to eating it with someone).”

Knowledge about the foods history (ingredients, origin and method of production) was mentioned at various times throughout the focus group as a determinant to satisfaction.

”the story behind it. If there’s a good story about what you’re eating, f. ex. that the animal has had a good life or that the wild garlic (ramson) has been picked in a certain forest. Don’t know if it can override the actual taste experience. But it can help.”

”if it should make me satisfied, then I need to know it’s (raw material) ok.”

Some participants were concerned about the health related food aspects, and addressed foods health value in relation to satisfaction. While some mentioned healthy foods as satisfying in themselves, by one being aware of eating what is considered to be “good for the body” others used healthy foods as a source to the real enjoyment of eating unhealthy foods. By eating the healthy foods they felt allowed to eat something unhealthy, indicating that they felt the need to balance their diet in order to be allowed to feel satisfied by the unhealthy food.

”What I eat, and if it’s healthy, is very important for me so it affects my satisfaction.”

”I’m satisfied by, if I eat something healthy, then I can eat something unhealthy later....there’s something about the other (the unhealthy) that’s delicious.”

3.5 Comparison of the importance of the various determinants to satisfaction

During the focus groups several factors was mentioned possible to alter the feeling of food satisfaction. Some participants compared the factors and discussed what meant the most to the feeling of satisfaction. Among the factors were “expectations, satiety and health value”. Common for all factors were, that they were evaluated up against the sensory experience, and the sensory experience was concluded to mean the most. This indicates that the sensory experience is unquestionable an important determinant of satisfaction, but consumers reflects upon the possibility, that other factors can match the importance of sensory palatability.

”when you make food, you should be inspired by your grandparents. They didn’t think about it (health) because they made food with cream. It was whipping cream, not low fat products, and it tastes a lot better.” (health vs. sensory experience).

”I like something healthy and it’s mostly what I choose, but there’s something about the other (the unhealthy) that’s really delicious. What about quality of life? What if I think I’ll be happy eating this? If it makes me happy then it’s good.” (health vs. Sensory experience as a source of quality of life).

”I’d rather go without, ...rather go away hungry than have a bad sensory experience.” (satiety vs. sensory experience).

3. Discussion

From the focus groups it was found that participants interpreted food satisfaction as a feeling that developed based on the consumed food, and that several factors influenced degree of satisfaction.

Hunger reduction was stated important for satisfaction, as participants in most situations could not imagine leaving a meal feeling hungry but satisfied. The importance of satiation is not surprising as initiation of eating often starts with a physiological need for nutrients, and fulfilment of this basic need is satisfying in itself. Though satiation was regarded a basic requisite for satisfaction, participants stated that it did not bring a pronounced hedonic experience, and though hunger was reduced other psychological desires could remain unfulfilled. In agreement with this, Murray reflect that it is possible to feel physical full and mentally hungry at the same time (Murray & Vickers, 2009), as participants in her study discussed how their stomach felt physically full of oranges, yet they were still hungry for other foods. Lowe and Butryn do in their study distinguish homeostatic and hedonic hunger (Lowe & Butryn, 2007). They regard homeostatic hunger as nutrient driven while homeostatic hunger is driven by a need for pleasure. The authors stated that while homeostatic hunger declined with satiation, satiation did not seem to have the same effect on hedonic hunger. Hedonic hunger can be a part of the reason why some foods are desired and consumed when no energy deficit exist. We believe that the mental hunger described by Murray and hedonic hunger described by Lowe and Buntryn relates to a desire for a certain sensory stimulation, and that satisfaction driven by perception of the foods sensory characteristics is necessary in order for consumers to feel fully satisfied (under normal circumstances). In the present focus group the importance of sensory characteristics for satisfaction was observed, as it was mentioned by all participants, and further as participants used sensory characteristics as a basis for comparison when reflecting upon other possible determinants. However, what comprised the sensory driven satisfaction was subjective. Several participants mentioned the importance of a varied, novel and surprising sensory experience, whereas others preferred foods they were familiar with and in advance knowing what to experience. Variety, novelty and surprise do together with complexity form a group of collative properties which has gained much attention within research (e.g. Berlyne, 1950; Mielby, Kildegaard, Gabrielsen, Edelenbos, & Thybo, 2012; Giacalone, Duerlund, Bøegh-Petersen, Bredie, & Frøst, 2014). According to Berlyne (Berlyne, 1970) a bell-shaped relationship exists between hedonic appreciation of a stimuli and its arousal potential. Contributing to the arousal potential are products collative properties (Berlyne, 1966). In agreement with what was observed from the focus groups, Berlyne (Berlyne, 1970) states, that arousal levels are subjective and therefor individual optimum levels can be found. Mojet and Koster (Koster & Mojet, 2007) and Van Trijp and colleagues (Van Trijp, Lähteenmäki, & Tuorila, 1992) have studied the subjective optimal arousal levels. Mojet and Koster observed that highly neophobic consumers had low optimal arousal levels preferring stimuli they were familiar with, whereas variety seekers preferred more novel and complex stimuli. Van Trijp and colleagues used the VARSEEK scale to classify subjects by their desire for variety in food consumption. They showed that while some strive for stability in their food choices others can be defined as so called "variety seekers". Taking into account the work done by Mojet and Koster and Van Trijp and colleagues, the observations from the focus groups about subjectivity in importance of collative properties, can be a result of individual differences in neophobic and variety-seeking status.

Sensory variation was not solely stated important within a meal but also found important between meals in order for consumers to be satisfied. This statement can reflect an innate need to ensure intake of an adequate amount of varied nutrients (Rozin, 1976), and to avoid a monotonous diet

sensory specific satiety (SSS) develop for recently eaten foods. SSS are defined as a decrease in pleasantness of the sensory properties of an eaten food relative to the pleasantness of uneaten foods (Rolls, 1986). Rolls et al studied the persistence of SSS, and found that SSS persisted one hour post intake (Rolls, Van Duijvenvoorde, & Rolls, 1984). Similar results were found by Hetherington and colleagues (M Hetherington, Rolls, & Burley, 1989) whereas Weenen and colleagues found SSS to persist two hours after intake (Weenen, Stafleu, & de Graaf, 2005). Studies investigating the persistence of sensory specific satiety over a longer time period than two hours are warranted, in order to be able to fully discuss the remarks of focus group participants about sensory variation between meals, as meals very often are separated with more than two hours.

Participants mentioned that in order to feel satisfied, they needed to experience an appropriate amount of energy and not to feel tired after food intake. According to participants different lunch meals could result in different levels of post lunch sleepiness. Monk (Monk, 2005) states that post lunch sleepiness can be seen as a bi-circadian rise in sleepiness during mid-afternoon. Previous studies have found, that fatigue and sleepiness are more likely with a lunch consisting of high fat/and or carbohydrates (Cunliffe, Obeid, & Powell-Tuck, 1997; Wells, Read, Idzikowski, & Jones, 1998; Wells, Read, Uvnas-Moberg, & Alster, 1997). Reyner et al studied the effect of energy content on post lunch sleepiness, and found increased ratings of sleepiness after consumption of heavy meals, defined as triple calorie content, compared to intake of light meals (Reyner, Wells, Mortlock, & Horne, 2012). Though the focus group did not go in-depth with macro-nutrient- or energy content, participants stated that heavy meals was related to post lunch sleepiness, and thereby confirm the studies of Reyner and colleagues.

The focus groups did not bring a discussion about how to understand satisfaction compared to liking. One interesting question is, do they reflect the same size of pleasantness or does satisfaction imply a more than averagely pleasant feeling? If satisfaction represent “something more than averagely pleasant”, can sensory characteristics then cause satisfaction or must other factors (satisfaction formatters) beside the sensory experience be present? Though the focus groups did not reflect upon these questions, three factors were stated to add “extra hedonic value” to the pleasurable sensory experience; knowledge about food history, healthy foods and the context in which the food was eaten.

Participants mentioned the fact of knowing the location of origin could add hedonic value to the eating experience. Knowledge about food history has been studied from different angles in the scientific literature. Stefani and colleagues studied how knowledge about food origin affected hedonic scores (Stefani, Romano, & Cavicchi, 2006). Origin are hypothesized to affect consumer’s evaluation in two ways; either as a quality cue by hinting to other characteristics such as sensory characteristics or by its symbolic role i.e. ethical values, authenticity or ability to awake memories of past experiences. Stefani and colleagues found information about origin to acts as a quality cue, and the more precisely defined the area of origin the higher quality expectations (Stefani et al., 2006). This study supports the statements from the focus groups indicating that knowledge about food history can add extra hedonic value. On a more overall level, the influence of knowing the food history on satisfaction might be related to the fact, that it allows transparency in the food production chain, and enables consumers to make conscious choices in line with their personal values e.g. animal welfare which was further highlighted important for some consumers in the focus group.

Healthy foods could for some focus group participants bring extra hedonic value, as the fact of knowing eating foods considered good for the body was satisfying in itself. Motives behind healthy eating have been studied by (Michaelidou, Christodoulides, & Torova, 2012) who found that intrinsic motives included “feeling better” and “staying healthy”. In contrast, one participant in our focus groups mentioned healthy foods and satisfaction to be related, as intake of healthy foods justified intake of palatable unhealthy foods. Raghunathan and colleagues studied the related question “what if people consume food that is considered unhealthy not despite its unhealthiness but *because* of it?” (Raghunathan, Naylor, & Hoyer, 2006). The authors found that consumers believe healthiness and tastiness are negatively correlated. Despite their findings, the hypothesis about unhealthy foods being more palatable is not supported scientifically. Rather the opposite is observed e.g. when studying the effect of energy reduction on hedonic ratings. Consumers who eat lower-energy-density food eat the same volume of the unmodified food (resulting in fewer calories consumed), rated themselves as equally satisfied and did not perceive the food tasting worse (Rolls, Ello-martin, & Tohill, 2004). Other factors besides tastiness might affect the perceived attractiveness of unhealthy foods. One such factor is non-conscious learning, studied through i.e. reward effects (Birch, 1984; Newman, 1992) and truth effects (Hawkins, 1992). Based on this, the distinction in palatability between healthy and unhealthy food done in the focus group, might be due various conscious as well as non-conscious effects.

Depending on context, participants in the focus groups mentioned that the same food could be perceived hedonically different. Research suggests least four major context effects that can alter the perception of food during consumption; its function as a meal component, social interaction during consumption, the environment and food choice freedom. There are several studies focusing on the context effects mentioned in the present focus group (social interaction and eating environment). King and colleagues conducted a study among average consumers and found that social context had a strong negative effect in a pizza situation (King, Weber, Meiselman, & Lv, 2004). One explanation for this effect is that people might feel uncomfortable eating a hand-held food in the presence of other people. This study further indicates that social context might be different depending on food product/meal. The finding that hedonic food perception is affected by the context in which it is eaten, is supported by Meiselman et al (2000), who found that acceptability ratings differed significantly across different environments. Different eating environments generate different expectations about the food to be consumed, and the expectations have shown to affect hedonic food perception in both assimilating (E.g. Cardello & Sawyer, 1992; Schifferstein, Kole, & Mojet, 1999; Tuorila, Cardello, & Leshner, 1994) and contrasting ways (Zellner, Strickhouser, & Tornow, 2004). Reviews by Cardello (2007) and Schifferstein (2001) suggest reasons to whether expectations can lead to assimilation or contrast effects. Firstly, the size of discrepancy: where the difference between actual and expected sensory stimuli is small, the difference may not be noted and assimilation takes place, whereas if discrepancy is large contrast effects may occur. A second factor is the strength of the expectation: even where there is large discrepancy between expected and actual properties, assimilation may occur if the expectation is very strong. Such findings are reported by Zellner et al (2001). Together these studies support the findings of the focus group stressing that food satisfaction can differ depending on social and environmental context and the context generate different expectations of the hedonic food experience.

4. Conclusion

The focus group interviews took us one step closer to an understanding of the complex term "food satisfaction", and how it is perceived from a consumer perspective. Multiple factors contribute to and can affect food satisfaction, and the importance of each factor can vary between subjects. Factors important for food satisfaction appear before as well as during and after intake. Before intake expectations and desires based on memories about previous food experiences and the context in which the food is perceived is important. All consumers desire a positive sensory experience, but what makes the sensory experience is subjective. Despite all subjects want the experience to match individual preferences, the optimal arousal level differs between subjects (and possibly also depending on context). Physical wellbeing was mentioned important for the feeling of satisfaction. Included in physical wellbeing was the experience of an appropriate energy level after intake. For most meals satiation is important in order for consumers to feel satisfied, however situations where satiation is of less importance do exist. In these situations the sensory perceptions during intake is the primary determinant. In general the sensory experience seems to be the primary determinant to satisfaction. The hedonic experience of eating could be enhanced by the social company and knowledge about the food incl. health value and origin. Together the focus group interviews highlighted determinants to food satisfaction, which could be included as response variables in future quantitative studies of factors influential in food satisfaction.

Acknowledgements

This work is a part of the SensWell study founded by the Danish Strategic Research Council, grant-no10-093479. Rie Kjeldsgaard Sørensen and Jeanette Unger Møller are thanked for their contribution to meal selection and following preparation and Hugo Ladefoged for his contribution photographing meals. Ditte Green-Petersen is thanked for her assistance during the focus group interview and generation of summaries and Karen Kliim-Hansen for her help translating consumer quotations from Danish to English.

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PII

Food satisfaction: Integrating feelings before, during and after food intake

Barbara Vad Andersen^{a*} & Grethe Hyldig^a

^aNational Food Institute, Department of Industrial Food Research, DTU, Soeltofts Plads, Building 221, DK-2800 Kgs. Lyngby, Denmark

**Corresponding author. E-mail address: bvan@food.dtu.dk Phone: 0045 45252548.*

Abstract

Consumers' satisfaction is important for the food industry to ensure product success. Determinants to food satisfaction are multifactorial and a method approaching the multiple determinants would provide a detailed picture of determinant behind consumers' hedonic food appreciation. The aims of this study were 1) to develop a method that could give detailed information about sensory- and food satisfaction 2) to study differences in sensory satisfaction in a case study, and 3) to study the factors related to food satisfaction. Focus group interviews and a literature study provided an overview of factors affecting food satisfaction. A total of four questionnaires, covering factors before-, during- and after intake as well as demographics, were developed to measure factors related to satisfaction. The questionnaires were utilised in a cross-over consumer study with 79 subjects consuming two sensory different variants of chicken soup. Further, soups were sensory evaluated utilising expert statements. The consumer study showed that sensory satisfaction was highly influenced by liking of taste and appearance. Liking of odour and texture influenced sensory satisfaction moderately. Food satisfaction was influenced by factors measured during- and post intake; sensory satisfaction, fulfilment of expectations, reason for ending intake, product performance relative to expectations, hunger and fullness after intake were found highly influential in food satisfaction. Pre-intake factors did not substantially influence food satisfaction. Though the use of multiple variables gave a detailed picture of factors involved in food satisfaction, there was still variation in food satisfaction that remained unaccounted.

Keywords

Sensory satisfaction. Food satisfaction. Food satisfaction determinants. Consumer study. Hedonic response.

Highlights

- Hedonic variables during intake relevant for sensory satisfaction have been understood
- Sensory satisfaction was best explained by liking of taste and appearance
- The variables pre-, during- and post intake relevant for food satisfaction have been understood
- Food satisfaction was best explained by sensory satisfaction, fulfilment of expectations, reason for ending intake, product performance relative to expectations, hunger and fullness

1. Introduction

Product satisfaction is an essential goal for the food industry when developing, maintaining, optimizing and evaluating their products (Stone & Sidel, 1993). Ratings of preference and acceptance are the most commonly used measures when studying, how products hedonically are perceived by consumers. Preference refers to liking/disliking of food names whereas acceptance refers to liking/disliking of foods that are tasted (Cardello, Schutz, Snow, & Leshner, 2000). Often acceptance ratings are combined with sensory descriptive analysis, to determine the sensory attributes responsible for differences in liking.

Despite the extensive use of liking ratings as single measures for hedonic food impression, researchers acknowledge that multiple factors before, during and after intake as well as contextual factors can affect consumers hedonic food impression. Cardello and colleagues suggest “satisfaction” as a more appropriate measure of consumers’ response to foods than liking (Cardello, Schutz, Snow, & Leshner, 2000), as they believe satisfaction to connote a more generalized appreciation of the food, incorporating a variety of situational aspects along with aspects related to the sensory food properties.

One such aspect is “expectations”. Expectations about liking are affected by memory of previous food experiences and a variety of contextual factors independent of the food itself. Previous studies have found, that when the difference between expected and experienced liking is relatively small, experienced liking move in the direction of expected liking, referred to as assimilation (Cardello & Sawyer, 1992; Schifferstein, Kole, & Mojet, 1999 and Tuorila, Cardello, & Leshner, 1994). On the other hand, if large differences between expected and experienced liking are perceived contrasting effects have been found (Zellner, Strickhouser, & Tornow, 2004 and Cardello & Sawyer, 1992).

Another factor that has been found to affect consumers’ hedonic food impression is the “appropriateness” of the food for the eating situation. While a food may be well liked if it is served in an appropriate situation, liking can decrease, if it is served in an inappropriate situation (e.g. Meiselman, Johnson, Reeve, & Crouch, 2000 and Rozin & Tuorila, 1993), and it was found important when measuring acceptance in laboratory settings (Cardello & Schutz, 1996).

Cardello and colleagues hypothesize, that satisfaction implies something about the food’s value, its utility and its adequacy for the situation. They showed that satisfaction was better predicted by pre- and post-consumption variables than acceptance or consumption measures (Cardello, Schutz, Snow, & Leshner, 2000). A focus group study, focusing on consumers’ views on determinants to food satisfaction backed up the assumptions done by Cardello and colleagues (to be published elsewhere). It was found that consumers mentioned expectations and desires pre intake, sensory properties during intake and physical well-being post intake (e.g. satiation, energy level) as well as various contextual factors (e.g. occasion), as determinants to satisfaction. What was missing from the focus group interviews was an evaluation of the importance of the single determinants to satisfaction. Together, the focus group interviews and the study by Cardello and colleagues suggested a need for more research to be focused on the variables influencing satisfaction.

The present paper describes the development and usage of a method measuring satisfaction with food. The method was meant to provide a detailed picture of the factors influencing consumers’ feeling of satisfaction, when satisfaction was measured post intake. Opposite to many studies conducted within sensory science, which primarily focused on liking of sensory properties, the present method included measures of subjective state and attitude pre-intake, hedonic evaluation of sensory properties during intake, well-being related sensations post intake and measures related to the specific subject; demographics and factors related to general attitude and behaviour towards the

specific food type. By including these factors a holistic investigation of consumers' food experience was applied. In the method two satisfaction terms were regarded key variables; sensory satisfaction and food satisfaction. Sensory satisfaction referred to the hedonic experience of the products sensory properties. Thereby, the term was closely related to the well-known measure of liking. Opposite to liking, which have been shown primarily to reflect liking of a foods taste/flavour (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz & Krieger, 1995), consumers were asked to express degree of satisfaction with the sensory food properties; appearance, odour, taste and texture altogether, when rating sensory satisfaction. It could thereby be assumed that consumers paid attention to all four sensory properties in their rating of sensory satisfaction. Food satisfaction was measured after intake, and the concept can be outlined as follows: food satisfaction was believed to represent a generalised hedonic response to the food. In this response the consumers were believed to evaluate sensations related to the sensory experience, psychological- and physical well-being (e.g. satiation, energy level) and conformity with expectations and desires. Regarded as such our measure of food satisfaction is comparable to the measure of "food quality" described by Ko (2009). However, in the present study "food satisfaction" differs from "food quality" by including measures of food induced physical- and psychological well-being and excluding extrinsic product characteristics (e.g. packaging and labelling). Regarded as such "food satisfaction" can be described as a positive response to the food, after perceiving it and food induced physical- and psychological well-being related sensations. To provide a detailed picture of the factors influencing food satisfaction, the study included measures of variables that from previous studies have been found to affect hedonic appreciation of foods.

The aims of this study were 1) to develop a method that could give detailed information about sensory- and food satisfaction 2) to study differences in sensory satisfaction in a case study 3) to study the factors influencing food satisfaction.

2. Method

2.1 Development of the method

The method is based on questionnaires that were given to consumers before, during and after intake.

2.1.1 Development of questionnaires

Questionnaires were developed based on a literature search of factors known to affect food satisfaction and two focus group interviews (unpublished). The focus group interviews served to enter the field of satisfaction from a consumer point of view, and aimed to study how consumers experienced satisfaction while eating and which factors they identified as important for a feeling of satisfaction. The literature study and focus group interviews provided an overview of factors with potential to affect satisfaction and did in general serve as a framework for the development of the questionnaires.

2.1.2 Pre-test of questionnaires

Prior to the consumer study (explained below), a pre-test of the questionnaires was carried out with 9 non-involved or otherwise uninformed employees. Pre-testing questionnaires is a general recommended procedure (Lawless & Heymann, 2010). The pre-test was followed by an interview among 4 of the employees, to check for inconsistencies and/or misinterpretations. After the pre-test the questionnaires were modified slightly; response categories were adjusted to be approximately identically for the sake of ease to fill out the questionnaires, and a few questions were added to facilitate pre- vs. post-intake comparisons and for the sake of precision. Further, the serving temperature was adjusted, so that the food was ready-to-eat at the time of serving.

2.1.3 Final questionnaires

Table 1 show the response variables included in the four questionnaires. In this section the response variables and scales for ratings are described. Questions were presented for consumers in the order presented here.

The first questionnaire should give the baseline of consumers' physical- and psychological state and attitude. It included ratings of: state of hunger, stomach fullness, overall physical- and psychological well-being, energy level, expected linking, strength of conviction (how confident consumers felt that their expectations would be fulfilled), desire to eat and appropriateness.

Questions were presented in the order presented here. The questions followed the form "do you feel...?" and were answered on a 9-point hedonic scale ranging from "no, extremely not" to "yes, extremely". The consumers filled out the first questionnaire *before* intake. Information about the soups was given in written form and only included information about the type of soup.

The second questionnaire was filled out *during* intake of the food product. Consumers were asked to rate: liking of the sensory attributes; appearance, odour, taste and texture and sensory satisfaction. Liking of sensory attributes were measured on a 9-point hedonic scale ranging from "dislike extremely" to "like extremely". "Sensory satisfaction" was measured by asking consumers to rate how satisfied they felt, when considering the appearance, odour, taste and texture all together. Ratings were given on a 9-point hedonic scale ranging from "extremely unsatisfied" to "extremely satisfied".

The third questionnaire was filled out immediately *after* intake. It included measures of: reason for ending intake, food satisfaction, product performance, state of hunger, stomach fullness, desire for other foods, desire to eat again, overall physical- and psychological well-being compared to before intake and energy level compared to before intake. Reason for ending intake was assessed using the fixed response categories: "I was satiated", "the food bored me", "the food felt unpleasant to eat", "my conscious told me not to continue eating" and "other reason" following a clarification. Fixed response categories were also used to asses product performance and included the categories: "worse than expected", "as expected" or "better than expected". Further fixed response categories were used to asses if physical- and psychological well-being and energy level had "increased", "decreased" or "was the same" as before intake. Food satisfaction was measured by asking "how satisfied are you with the soup right now?" and consumers rated satisfaction on a 9-point labelled scale ranging from "extremely unsatisfied" to "extremely satisfied". Questions about fulfilment of expectations, state of hunger, stomach fullness and desire to eat again followed the form "do you feel...?" and rated on a 9-point hedonic scale ranging from "no, extremely not" to "yes, extremely". The question "do you feel like having anything else to eat or drink?" aimed to indicate if the consumer had fulfilled all sensory needs. The fixed response categories were "no", "yes, but I do not know what" and "yes" including a clarification. A comment field was included at the end of each questionnaire, allowing consumers to clarify issues important for their subsequent evaluation of the product.

The fourth questionnaire concerned background information on: socio demographic, general behavioural and attitudinal variables. This questionnaire was filled out at the end of *the last day* consumers participated in the study. Consumers were asked to indicate: gender, age, educational level, height and weight, if they liked tasting new foods, general liking of soups and frequency of soup consumption. Age was indicated in the pre-typed response categories: < 25 years, 25-40 years, 41-55 years or \geq 56 years. Educational level in the categories: lower secondary, higher secondary, higher secondary with trainee, short-length higher education (\leq two years), medium-length higher education (two to four years), long higher education ($>$ four years). Soup consumption frequency in the categories: \geq once per week, 2-3 times per week, once per month, 1-5 times per half year and <

once per half year. General food liking and general attitude towards new foods were rated on a 9 point hedonic scale ranging from “dislike extremely” to “like extremely”.

Table 1. Response variables included in questionnaires used in the consumer study. Questions were presented in the order presented here. Information about scales applied can be seen in section 2.1.3

Pre intake variables	During intake variables	Post intake variables	Socio demographic data and general behavioural and attitudinal variables
Hunger	Liking of appearance	Reason for ending intake	General like to taste new foods
Stomach fullness	Liking of odour	Food satisfaction	Soup consumption frequency
Physical wellbeing	Liking of taste	Fulfilment of expectations	General soup liking
Psychological wellbeing	Pleasantness of after taste	Product performance	Gender
Energy level	Liking of texture	Hunger	Height
Expected liking	Sensory satisfaction	Stomach fullness	Weight
Strength of conviction about expected liking		Desire for other foods	Educational level
Desire to eat soup		Desire to eat again	Age
Appropriateness for time of day		Physical well-being compared to pre intake	
		Psychological well-being compared to pre intake	
		Energy level compared to pre-intake	

2.2 Consumer study

The questionnaires were used in a cross-over study with ad libitum intake of two sensory different variants of the same creamy chicken soup. The consumers tested only one soup in each session. 79 consumers were recruited for a central located consumer test. Participant characteristics can be seen in table 2. One participant was left out of the analyses due to many missing values, thus in total 78 subjects was included.

Table 2. Participant characteristics for subjects in consumer study

Characteristic	
N_{total} ^a	78
Gender (male/female) ^a	39/39
Age (years) ^b	42 (25, 60)
BMI ^b	25.9 (18, 49)
Educational level ^c	3.7 (1, 5)
General like to taste new foods ^d	7.2 (± 1.0)
General liking of soups ^e	7.6 (± 0.9)
Desire after meal ^f	5,4 (± 2.0)

^a Number

^b Mean (min, max)

^c Mean (min, max) 1: public school 2:high school/higher commercial or technical school 3:vocational education 4: short/medium length education 5:long education

^e Mean (std.). Measured on a 9-point scale ranging from “do extremely not” to “do extremely”

^d Mean (std.). Measured on a 9-point-hedonic-scale ranging from “dislike extremely” to “like extremely”

^f Mean (std.). Measured on a 9-point scale ranging from “no extremely not” to “yes, extremely”

The recruitment was conducted by a recruitment agency calling randomly selected telephone numbers in the local area of the institute emphasising an even distribution of gender, age and educational level. Inclusion criteria was consumers of soup; within the age range 25-60 years who liked chicken soup and were not working with food production, nor suffering from illness or food allergies. Each consumer was instructed not to eat two hours preceding the study. Participants completed two test meals with one meal per day at 12, 15 or 6:30 PM. Preferably participants came in at the same time both days. Participants were even divided into two groups. Group 1 consumed soup A on the first day and soup B on the second. Group 2 consumed soup B on the first day and soup A on the second. Soup variant A was a creamy chicken soup with an energy content of 230 kJ/100 g. Soup variant B consisted of the same creamy chicken soup added pieces of chicken, vegetables, parsley and croutons and had an energy content of 256 kJ/100g.

Testing took part in sensory booths to minimize the inter-human effect on intake and evaluation of the soups. The soups were prepared following a standardized procedure and served at pre weighted amounts. A portion of soups was approximately 2 dl for soup A and approximately 1.5 dl soup, 20g chicken meat, 40g vegetables, 10 croutons and 1 teaspoon parsley for soup B. The subjects were instructed to eat until they did not feel like eating anymore. If a portion was finished another serving was offered. Number of servings was recorded as well as total intake with a precision of 1 g. The questionnaires were handed out before-, during- and after intake and the fourth questionnaire, for collecting demographic and background data, after intake in the second session.

During the consumer study 15 subjects (7 males, 8 females) were monitored using the Noldus Media Recorder (software version 2.0) for the purpose of validating if questionnaires were filled out as instructed and detecting difficulties. After recruitment consumers were contacted and asked if the test could be monitored. Participants were informed that the recordings were used as documentation and would only be shown to employees working with on the project. Only consumers who gave oral contentment were finally monitored. The recording did not reveal any difficulties.

2.3 Objective sensory evaluation

Expert statements were obtained using 5 members of an expert panel at the National Food Institute, the Danish Technical University. The panel had 1-25 years of experience in sensory evaluation. The panel focused on the attributes: odour (vegetable, chicken), flavour (salty, vegetable, chicken) and texture (creamy, solidity) for both soups. For soup B the attributes further included: texture (chicken toughness, vegetable crispiness, crouton crispiness) and flavour (parsley). Intensity of parsley flavour and crouton crispiness was evaluated at serving time and after three minutes. Different evaluation sheets were used for the two soups. An expert sensory evaluation was chosen because of relative explicit differences between soups. Pictures of the soups can be seen in figure 1.



Figure 1. Pictures of creamy chicken soups used as study matrix. To the left: soup A. To the right: soup B

2.4 Statistical analysis

Pre-intake response variables (perceived: hunger, stomach fullness, physical- and psychological well-being, energy level, expected liking, strength of conviction and appropriateness) were analysed using pairwise comparisons to determine if consumers differed before evaluating the soups. The open source software Prism (GraphPad Prism 4.03) was used.

During intake response variables (liking of appearance, odour, taste and texture) were analysed using a mixed model investigating product main effect to determine consumer's hedonic impression of the soups sensory characteristics. For each variable, products were set as fixed effect and consumers as random effect.

Post intake response variables (intake, food satisfaction, hunger, stomach fullness, fulfilment of expectations and desire to eat again) were analysed for a product main effect. The categorical values: Reason for ending the meal, desire for other foods, product performance, energy level post intake, physical- and psychological well-being were analysed by chi-squared test.

Data on weight and height was used to calculate BMI: $\text{weight (kg)/height (m)}^2$. Demographic and background data (BMI, gender, education, age, time for conducting the test, liking of food in general, liking of soup in general and soup eating frequency) were analysed for potential main effect on sensory satisfaction and food satisfaction. Two-way interaction effects were: product*BMI, product*gender, product*education, product*Age and product*time for conducting the test.

Mixed models were carried out in XLSTAT (version 2014.3, addinsoft S.A.R.L), subjects were set as random factor and missing data was removed from the analysis. Limit for statistical significance was in all analysis set to 0.05.

Two Partial Least Square Regression (PLSR) models were applied; one to find the variables influential in sensory satisfaction and one to find the variables influential in food satisfaction. In the first model, sensory satisfaction was set as response variable (Y-variable) and during intake response variables: liking of appearance, odour, taste and texture as predictors (X-variables). In the second model food satisfaction was set as response variable (Y-variable) and pre-, selected during- and post intake variables, socio-demographic, general behavioural and attitudinal variables as predictors (X-variables). A response variable was kept out of the analysis, if the meaning of the variable were covered by other variables. Sensory satisfaction measures consumers' hedonic response to appearance, odour, taste and texture altogether, for which reason liking of the single properties were kept out of the analysis. Desire to eat again was left out of the analysis as it could be regarded a consequence of food satisfaction rather than a determinant. For demographic data, consumers were grouped based on BMI status; under-weight (<18.5), normal-weight (18.5-24.9), overweight (25-29.9) and obese (>30). For consumption frequency, educational level, and age consumers were grouped as indicated in section 2.1.3. For the purpose of increasing visualisation, figure 3 in section 3.1.4 only include response variables which were influential in food satisfaction. A lower limit of $Q^2_{\text{cum}} = 0.6$ was used as a criterion for a good PLSR model. To determine the variables influential in sensory- and food satisfaction Variables Important in Projection scores (VIP) was analysed. Only variables with VIP score > 0.8 were regarded influential; a VIP score between 0.8 and 1 has previously been defined as moderate influential and a VIP score > 1 highly influential (Eriksson et al, 2001; Wold, 1995). PLSR was run on consumer data across products. Explanatory variables were centered and reduced.

One participant was left out of the analyses due to many missing values, thus in total 78 subjects was included. PCA, PLSR and calculation of VIP scores were carried out in XLSTAT (version 2014.3, addinsoft S.A.R.L).

3. Results

3.1 Consumer study

3.1.1 Pre-intake measurements

As can be seen from table 3, participants did not differ in pre-intake ratings of: state of hunger, stomach fullness, overall physical- and psychological well-being, energy level, strength of conviction and appropriateness. Expected liking and desire to eat ratings differed significantly between the soups when calculating the p-value across test days and randomisation. However, when calculating the p-value for the first test day no significant difference was seen in consumer ratings of soup A and B for expected liking and desire to eat, indicating a similar level of expectations and desires prior to the study. When analysing expected liking and desire to eat solely for the group of consumers having soup A on day one versus day two, the consumers had significantly higher expectations and desires on the first day of testing than on the second day ($p = .0326$ and $p = .0080$), indicating that participants lowered their ratings of expected liking and desire following intake of soup A (results not illustrated). The consumers having soup B increased their expected liking and desire to eat, though it was not significant.

Table 3. Mean and standard deviations of pre-intake response variables for soup A and B, inclusive p-values for comparison of soup A and B. Variables were measured on a 9 point scale. N=78.

Variable	Soup A		Soup B		Significance
	Mean	St. Dev	Mean	St. Dev	
Hunger	6.6	1.0	6.6	1.0	NS
Stomach fullness	3.2	1.1	3.2	1.2	NS
Physical wellbeing	7.2	1.1	7.4	0.9	NS
Energetic	6.0	1.6	6.1	1.5	NS
Psychological wellbeing	7.2	0.7	7.2	0.8	NS
Expected liking	7.0	1.0	6.7	1.1	0.0458
Strength of conviction	6.6	1.1	6.4	1.1	NS
Desire to eat	6.9	1.1	6.7	1.2	0.0282
Appropriateness	7.3	1.4	7.3	1.0	NS

NS= no significance

3.1.2 During-intake measurements

Table 4 shows higher ratings of liking of sensory properties; appearance, odour, taste and texture of soup B compared to soup A. Sensory satisfaction was rated 5.3 and 7.0 on a 9 point hedonic scale for soup A and B respectively corresponding to a significant difference between the soups. Mixed model showed a significant main product effect for all during-intake variables.

Table 4. Mean and standard deviations of during-intake variables measured for soup A and B, inclusive p-values for main product effect. Variables were measured on a 9 point hedonic scale and. N=78

	Appearance	Odour	Taste	Texture	Sensory satisfaction
Soup A: Mean (std.)	5.3 (1.7)	6.3 (1.4)	6.4 (1.4)	6.4 (1.4)	5.3 (1.8)
Soup B: Mean (std.)	7.7 (1.0)	6.8 (1.4)	7.1 (1.2)	7.4 (1.1)	7.0 (1.4)
	p-value	p-value	p-value	p-value	p-value
Product	< 0.0001	0.009	< 0.0001	< 0.0001	< 0.0001

PLSR was performed to study influential during-intake variables in sensory satisfaction. A two-component model was obtained with a Q^2_{cum} of 0.755 indicating a good model. The first component explained 63% and 72% of X- and Y-data respectively, and the second component explained 10% and 5% of X- and Y-data respectively. Analysis of VIP scores showed (figure 2) that liking of taste (VIP-score: 1.2) and liking of appearance (VIP-score: 1.0) were highly influential in sensory satisfaction. Liking of texture (VIP-score: 0.8) and odour (VIP-score: 0.8) were moderately influential in sensory satisfaction. Liking of sensory properties: appearance, odour, taste and texture all correlated positively with sensory satisfaction.

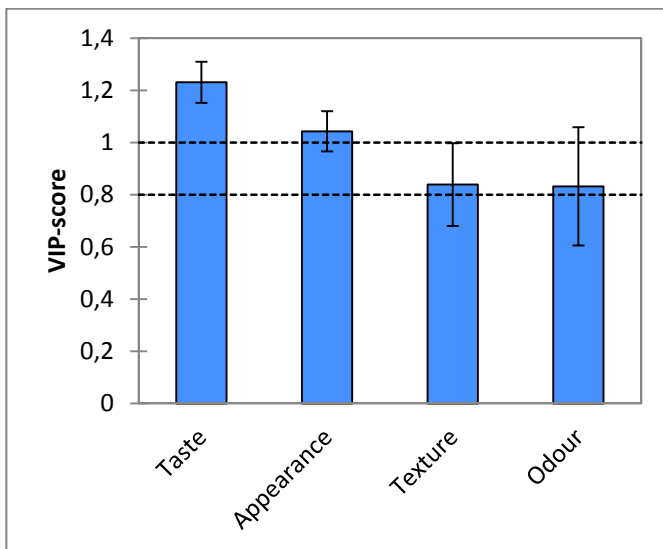


Figure 2. Variables important in projection (VIP) scores for liking of: taste, appearance, texture and odour. VIP-scores are calculated based on a PLSR model with sensory satisfaction as Y-data and liking of: appearance, odour, taste and texture as X-data. A VIP-score > 1.0 are considered highly influential in sensory satisfaction, and a VIP score between 0.8 and 1.0 are considered moderately influential in sensory satisfaction. Error bars are 95% confidence intervals.

3.1.3 Post-intake measurements

Mixed model showed a main product effect on intake and post intake variables: food satisfaction, hunger, stomach fullness, fulfilment of expectations and desire to eat again (table 5).

Reason for ending the meal differed significantly ($p < .0001$); with more people reporting satiety ($n_{\text{soupA}} = 23$ and $n_{\text{soupB}} = 42$) and fewer reporting getting tired of the food ($n_{\text{soupA}} = 32$ and $n_{\text{soupB}} = 5$) when comparing the eating of soup B to soup A (results not illustrated). As can be seen from table 4, food satisfaction for soup B was rated 7.2 on the 9 point hedonic scale whereas soup A received a rating of 5.6. Soup B received higher ratings of fulfilment of expectations compared to soup A. Further, more consumers reported the soup B as better than expected ($n_{\text{soupA}} = 14$ and $n_{\text{soupB}} = 61$) compared to soup A (results not illustrated). Consumers were less hungry, gave higher ratings of stomach fullness and desire to eat again after eating soup B (table 4). Likewise after eating soup B, significant fewer felt like eating/drinking anything else ($p < .0315$, $n_{\text{soupA}} = 51$ and $n_{\text{soupB}} = 36$). When asked to compare how they felt before and after intake (results not illustrated), significant more consumers felt increased physical- ($p < .0124$, $n_{\text{soupA}} = 14$ and $n_{\text{soupB}} = 28$) and psychological well-being ($p < .0257$, $n_{\text{soupA}} = 18$ and $n_{\text{soupB}} = 6$) after intake of soup B compared to after intake of soup A. No difference was found in perceived energy level after intake. The average number of servings ($n = 1.6$ servings ± 0.7) of soup B was significantly higher than soup A ($p < .0001$, $n = 1.4$

servings \pm 0.6). Converted to kilo joule, mean intake corresponded to 935 and 595 kJ for soup B and A respectively.

Table 5. Mean and standard deviations of post-intake variables for soup A and B, inclusive p-values for main product effect on post-intake variables. Variables were measured on a 9 point scale. N=78

	Intake (g)	Food satisfaction	Hunger	Stomach fullness	Fulfilment of expectations	Eat again
Soup A: Mean (std.)	259.3(174.7)	5.6 (1.9)	4.5 (1.7)	5.2 (1.8)	5.0 (1.9)	4.7 (2.1)
Soup B: Mean (std.)	352.3(187.2)	7.2 (1.4)	3.3 (1.6)	5.9 (1.7)	7.1 (1.4)	6.7 (1.6)
	p-value	p-value	p-value	p-value	p-value	p-value
Product	< 0.0001	< 0.0001	< 0.0001	0.003	< 0.0001	< 0.0001

3.1.4 Demographic data

No significant main effect were found for background data: BMI, gender, education, age, time for conducting the test, liking of food in general, liking of soup in general and soup eating frequency on sensory- and food satisfaction. Nor were significant interactions: product*BMI, product*gender, product*education, product*Age and product*time found on sensory- and food satisfaction.

3.1.5 Dimensions involved in food satisfaction

PLSR was performed to find the variables influential in food satisfaction. A two-component model was obtained with a Q^2 cum of 0.77, indicating a good model. The first component explained 11% and 77% of X- and Y-data respectively, and the second component 5% and 8% of X- and Y-data respectively. Analysis of VIP-scores showed that the following variables were highly influential in food satisfaction: Sensory satisfaction, fulfilment of expectations, product performance worse than expected, product performance better than expected, fullness, ending the meal due to boredom, ending the meal due to satiation and hunger. No response variables were found moderately influential. For the purpose of ease visualisation of correlations between response variables, figure 3 only includes response variables which were found influential in food satisfaction. VIP-scores for highly influential variables are shown in table 6, inclusive an indication of whether the single response variables contributed positively or negatively to the model.

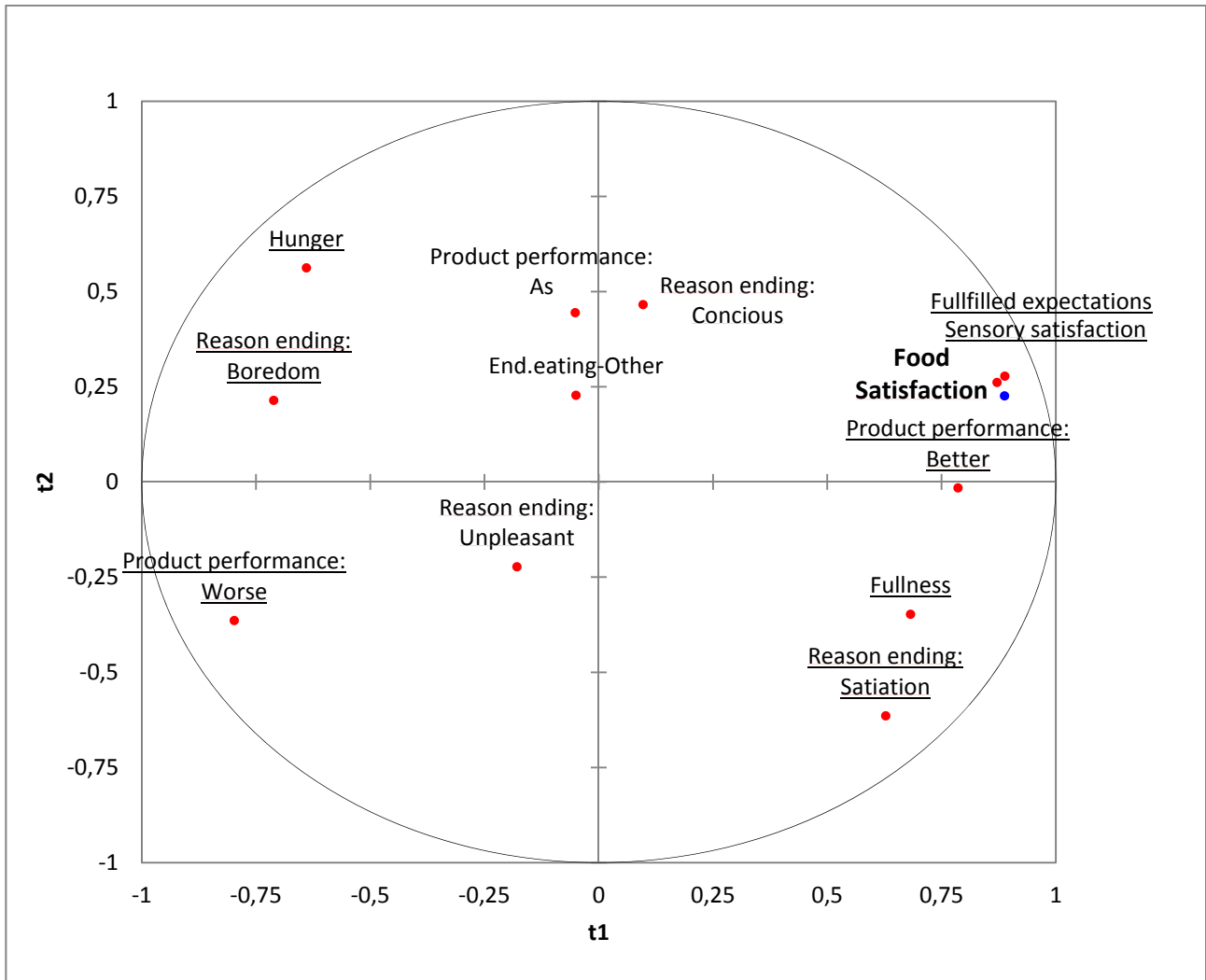


Figure 3. Partial Least Square Regression model (PLSR) with food satisfaction as response variable (Y-data), and sensory satisfaction, fulfillment of expectations, product performance, reason for ending intake, fullness and hunger as predictors (X-data). Predictors influential in food satisfaction are underlined.

Table 6. Variables important in projection (VIP) scores for sensory satisfaction, fulfilment of expectations, product performance, fullness, reason for ending intake and hunger. VIP-scores are calculated based on a PLSR model with food satisfaction as Y-data and selected pre-, during- and post-intake variables, socio-demographic, general behavioural and attitudinal variables as X-data. A VIP-score > 1.0 are considered highly influential in sensory satisfaction, and a VIP score between 0.8 and 1.0 are considered moderately influential in sensory satisfaction.

Variable	VIP score	Direction
Sensory satisfaction	3.0	Positive
Fulfilment of expectations	2.8	Positive
Product performance		
Better	2.2	Positive
Worse	2.5	Negative
Fullness	1.8	Positive
Reason for ending intake		
Satiation	1.4	Positive
Boredom	1.7	Negative
Hunger	1.5	Negative

3.2 Objective sensory evaluation

The basis soup used in the two soup variants was the same. Adding chicken, vegetables, croutons and parsley in soup B resulted in a market increased complex appearance as can be seen from the pictures in figure 1. Only a minor increased vegetable and chicken odour, flavour and creamy texture was perceived by the panel when focusing solely on the basis soup after adding filling. Further, a minor decreased salty taste and solid texture was reported for soup B. The chicken in soup B were reported very tough and the vegetables crispy. At the time of serving, the parsley flavour intensity was high and crouton crispiness very high. After three minutes parsley taste decreased remarkable as well as crouton crispiness. For soup A every spoonful of soup gave a simple, uniform sensory experience, whereas the sensory experience when eating soup B could vary for each spoonful depending on the chosen ingredients.

4. Discussion

When studying the dimensions explaining food satisfaction, variables measured during- and post intake contributed to explain most of the variation in food satisfaction. Variation in sensory satisfaction was mostly explained by variation in liking of appearance and taste.

4.1 Pre-intake variables

The fact that pre-intake variables, measured across subjects, did not differ among soups prior to intake, indicate that it was not a differences in these variables that caused different hedonic evaluations of the two soups. The results from PLSR model showed that the pre-intake response variables did not substantially influence food satisfaction in the present study (result not shown). However, this does not indicate that the variables were irrelevant as they provided information about consumers' level of expectations and whether the food is appropriate at the specific time point. This type of information is useful for the industry when targeting their meals.

4.2 During intake variables

Soup B was rated higher than soup A in liking of all sensory attributes (appearance, odour, taste and texture) and sensory satisfaction. The higher ratings of soup B can be explained by Berlyne's theory of a bell-shaped relationship between hedonic food appreciation and arousal potential (Berlyne, 1966, 1970). Contributing to the arousal potential are properties such as complexity, novelty, surprise and variability. Products with low arousal potential and therefore low levels of e.g. variability are not stimulating and leave the consumer indifferent. Products with very high arousal potential are considered unpleasant because they are too difficult for consumers to grasp and will likewise receive low hedonic ratings. The preferred products are those with a medium (or optimum) arousal potential. Though variability were not measured directly in the present study, the list of ingredients and general product description characterised soup B as a more varied soup than soup A. In support of this, Berlyne (1966) argued that variability increased when the number of elements and dissimilarity between elements increased. The more varied sensory experience when eating soup B can thus explain the higher hedonic ratings of this soup. The theories of Berlyne have been widely applied to explain sensory preferences, in most cases using visual stimuli (e.g. Mielby, Kildegaard, Gabrielsen, Edelenbos, & Thybo, 2012) and infrequent taste stimuli (Giacalone, Duerlund, Bøegh-Petersen, Bredie, & Frøst, 2014). Both studies revealed patterns in line with Berlyne's predictions. In support of the findings in the present study, Ko (2009) conducted a study focusing at factors affecting foodservice satisfaction. Results showed, food variety as important for satisfaction. Important to mention is that in Ko study, variety did not only refer to sensory variety within a meal, but also variety between meals, in meal offerings.

Liking of sensory properties were all found influential in sensory satisfaction (figure 2 and 3); liking of taste and appearance were found highly influential, and liking of odour and texture were found moderately influential. In support of these findings, previous studies have found liking of taste to be most important driver of overall liking (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz & Krieger, 1995). The sensory characteristics of the two soups can be used to explain why liking of odour and texture influenced sensory satisfaction moderately, when taste and appearance influenced sensory satisfaction highly. The objective sensory evaluation found that the odour only varied slightly between the two soups despite the large difference in ingredients. Further, the objective sensory evaluation characterised the chicken in soup B as tough, and crispiness of croutons was markedly decreased after three minutes. These characteristics could have lowered hedonic ratings (at least for some consumers) and decreased differences between liking of odour and texture for soup A and B.

The PLSR model (figure 3) showed sensory satisfaction as highly influential in food satisfaction. Thereby, our results support the broad range of studies and models focusing on: sensory properties and acceptance (e.g. Harper, 1981; Land, D.G., 1983; Tuorila, 2007), sensory properties and preference (e.g. Khan, 1981) and sensory properties and food behaviour (e.g. Cardello, 1996; Fürst et al., 1996; Connors et al., 2001; Mojet, 2007) which all recognise sensory properties as influential in hedonic food perception. Comparable to the present study, Ko (2009) established a model on foodservice satisfaction and investigated if a causal relationship could be found between satisfaction and food variety, sensory feeling and quality perception. In addition to finding a causal relationship, the study supports the findings in the present study, as sensory feelings had a great effect on overall satisfaction.

The high positive correlation between sensory - and food satisfaction found in the present study could also be an effect of the position of questions in the questionnaires. Recall from table 1, sensory satisfaction was rated last during intake, and food satisfaction was rated second immediately after intake. Thereby the questions were placed close together (in time). It is likely that sensory perceptions were highly present in consumers' mind, causing consumers' ratings of food satisfaction primarily to be based their rating of sensory satisfaction. Future studies will have to clarify, if ratings of food satisfaction collected a longer time span likewise produce highly positive correlations between sensory satisfaction and food satisfaction, or if sensations related to e.g. physical well-being will be the most influential variables in food satisfaction.

4.3 Post intake variables

Among the post-intake response variables reason for ending intake, product performance, fulfilment of expectations, hunger and fullness were found influential in food satisfaction.

Deliza and MacFie developed a model on the role of expectations in food choice and sensory perception (Deliza & Macfie, 1996). They predicted that confirmed expectations lead to a neutral feeling, whereas disconfirmed expectations lead to either satisfaction or dissatisfaction depending on whether the disconfirmation was positive or negative. Positive disconfirmation was predicted to cause satisfaction, and negative disconfirmation to cause dissatisfaction. Results on "product performance" in the present study confirm the predictions done by Deliza and Macfie (1996). In our study, the response categories "better than expected" and "worse than expected" both reflected disconfirmed expectations. As predicted by Deliza and Macfie, positive disconfirmation (better than expected) influenced food satisfaction positively, and negative disconfirmation (worse than expected) influenced food satisfaction negatively. The final category "product performance as expected" did not influence food satisfaction. Interesting, the response category "fulfilment of

expectations” were found highly influential in food satisfaction, despite this measure was meant to reflect the same response as “product performance as expected”. When reflecting on the phrasing the question about fulfilment of expectations, “do you feel your expectations are fulfilled?”, the question itself did not guide consumers in how to interpret or answer the term. Therefore, what consumers focused on when answering the question could have varied between subjects. It is likely that instead of only considering expectations prior to intake, consumers passed on their subjective hedonic perception of the soup to the evaluation of “fulfilment of expectations”. For future studies, a more specific phrasing of the question would be advisable or simply leaving out the question and keep the question about product performance.

When focusing on ratings of expected liking, no difference was found prior to intake of soup A and B on the first session. In the second session ratings of expected liking were significantly lower for among consumers who had soup A in the first session. This finding indicates that product performance from the first session contributed to lower consumers’ expectations in the second session (Deliza & Macfie, 1996).

In the present study expected liking was measured knowing the food item (written), but without experiencing any of the sensory properties. Expected liking ratings in the first session therefore solely relied on non-experimental sources of information such as emotional memories, self-knowledge and intuitive theories. Clear chicken soup with added vegetables and chicken is a well-known course in Denmark. It could very well be that consumers’ expectations rely on past experiences with this type of soup. After intake a significant higher rating of fulfilment of expectations were found soup B compared to soup A. These findings harmonise with soup B being more like the traditional Danish chicken soup. The large discrepancy between expected liking and experienced liking for soup A could have increase the possibility of contrasting effect. If contrasting effects occurred it would have caused consumers ratings to be more negative than they would have been without the expectations. Contrasting effects due to large differences between expected liking and hedonic perception have been found in studies by Yeomans and colleagues (Yeomans, Chambers, Blumenthal, & Blake, 2008), Zellner and colleagues (Zellner, Strickhouser, & Tornow, 2004) and Cardello and Sawyer (Cardello & Sawyer, 1992).

Hunger and fullness post intake was found highly influential in food satisfaction; hunger influenced food satisfaction negatively and fullness influenced food satisfaction positively. Similar findings have previously been reported and related to the fact that most meals initiate due to hunger (Murray & Vickers, 2009). When hunger was reduced following intake, a feeling of satisfaction was reported. In the present study, consumers gave significantly lower ratings of hunger and higher ratings of fullness after intake of soup B compared to after intake of soup A. This finding reconcile with the higher total intake of soup B. The more varied sensory properties of soup B could have caused these findings (Rolls, Rowe, Rolls, Kingston, Megson & Gunary, 1981). Rolls and colleagues found that subjects ate significantly more, when yoghurts distinctive in taste, texture and colour were offered, than when offered yoghurts with just one flavour. The effect of variety on intake are supported by several other studies (Norton, Anderson, & Hetherington, 2006; Remick, Polivy, & Pliner, 2009 and Epstein, Robinson, Roemmich, Marusewski, & Roba, 2010). Havermans and Brondel argued that the variety effect could (at least partly) be explained by consumption of other food items disrupted sensory specific satiety (SSS) (Havermans & Brondel, 2013). SSS refers to a change in hedonic response to the sensory properties of a particular food, as it is consumed (B. Rolls, 1986) SSS is shown by the pleasantness of the eaten food decreases significantly more than pleasantness of uneaten foods. Though pleasantness was not measured after intake in the present study, consumers’ ratings of “reason for ending intake” and “desire for other foods” indicated that SSS caused consumers to end their intake of soup A. For soup A, “the food bored me” was the

primarily reason for ending intake, whereas the primary reason for ending intake of soup B was “satiation”. After intake of soup A, significantly more felt a desire for other foods. Boredom could therefor reflect SSS in the specific case. In the PLSR model, “ending the meal due to satiation” influenced food satisfaction positively, whereas “ending the meal due to boredom” influenced food satisfaction negatively.

4.4 Socio demographic, general behavioral and attitudinal variables

In the present study it was further explored if background data influenced food satisfaction. Neither of the socio demographic-, general behavioral- or attitudinal response variables was found to influence food satisfaction.

4.4. Limitations

Limitations of this study were the use of products from only one product category. Thereby we have no indication of whether the findings can be generalised to other foods. Further, the use of a lab context does not reflect real life consumption.

With special attention to the factors related to sensory satisfaction, liking of: appearance, odour, taste and texture was chosen in the method. It could be relevant to include measures of collative properties and liking of tactile food perception as well, as well as attributes more specific for the type of food being studied. This would bring an even more detailed information on hedonic product perception in the specific case. It could further be relevant to include sensory descriptive analysis in future studies, as this would allow the study of sensory characteristics responsible for variation in sensory satisfaction.

As food satisfaction is believed to imply a generalized impression of the food, it could further be relevant to include measures during or following digestion. Factors that, through focus group interviews, were found relevant for satisfaction were: perceived stomach feelings, energy level and satiety (to be published elsewhere) in a longer timespan than immediately after consumption.

5. Conclusion

A method measuring sensory- and food satisfaction was tested in a cross-over study on two sensory variants chicken soup. The method holds potential for providing the food industry and/or sensory scientists with a detailed understanding of 1) the hedonic variables during intake important for the feeling of sensory satisfaction and 2) the variables pre-, during- and post intake important for the feeling of food satisfaction. In the present study, sensory satisfaction was primarily influenced by liking of taste and appearance, but liking of odour and texture influenced sensory satisfaction as well. This tells product developers primarily to focus on taste and appearance-related attributes when developing or optimising chicken soups, but attributes related to odour and texture cannot be neglected. Variation in food satisfaction was primarily related to sensory satisfaction, fulfilment of expectations, product performance relative to expectations, reason for ending intake, fullness and hunger post intake. Thereby the present study supports previous findings showing the important of sensory properties in food satisfaction. Also, we recommend measuring sensations related to physical well-being and performance relative to expectations as it can provide detailed information on the products important for satisfaction.

Though the use of multiple variables gave a detailed picture of factors involved in food satisfaction, a considerable part of the variation in food satisfaction remained unaccounted. Further, for future studies other types of food products are warranted to give a more general understanding of food satisfaction.

Acknowledgements

This study is a part of the Senswell project funded by Innovation Fund Denmark (grant no. 0603-00418B). Rie Kjeldsgaard Sørensen, Jeanette Unger Møller and Ditte Green-Petersen are thanked for their contribution to meal preparation and conducting the consumer study.

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PIII

The effect of protein content and study context on consumers' rating of hunger, fullness and food satisfaction. A case study using yoghurt with muesli products.

Barbara Vad Andersen^{a*}, Hilde Kraggerud^b, Per Bruun Brockhoff^c & Grethe Hyldig^a

^a*National Food Institute, Department of Industrial Food Research, DTU, Soeltofts Plads, Building 221, DK-2800 Kgs. Lyngby, Denmark*

^b*TINE R&D Ctr, N-4068 Stavanger, Norway*

^c*DTU Compute, Danish Technical University, Matematiktorvet, Building 324, DK-2800 Kgs. Lyngby, Denmark*

**Corresponding author. E-mail address: bvan@food.dtu.dk Phone: 0045 45252548.*

Abstract

This study assessed whether yoghurt w/muesli products, varying in protein content (normal vs. high) and two versions of muesli (dominated by nuts vs. berries), influenced hunger, fullness and food satisfaction when the study was conducted in a lab- and in a natural context. In total, 239 consumers participated in the study; 107 in the lab context and 132 in the natural context. The design followed an incomplete design, where two of four yoghurt w/muesli products were consumed and evaluated by each consumer. Approximately the same number of consumers evaluated each yoghurt w/muesli combination. Pre intake measures included: hunger and fullness, immediately post intake measures included: hunger, fullness and food satisfaction, and one hour post intake measures included: hunger and food satisfaction. Products, regardless of protein content, muesli variant and study context led to reduced hunger and increased fullness. No difference in hunger was found between products. Fullness was significantly higher for the high-protein products compared to the normal-protein products, but only in the lab study. A muesli effect was found on food satisfaction, where the nut variants received highest satisfaction ratings. This effect was only apparent in the lab study. An effect of study context (lab versus natural context) was found on immediately post intake ratings of hunger, fullness and food satisfaction ratings.

Highlights

- A significant difference in food satisfaction was found among yoghurt w/muesli products. The differences were demonstrated due to a main muesli effect, not a yoghurt effect.
- Differences in fullness following intake of combined yoghurt w/muesli products were shown due to a main yoghurt effect.
- An effect of context (lab- vs. natural context) was found on hunger, fullness and food satisfaction ratings immediately post intake, and on one hour post intake ratings of food satisfaction.

1. Introduction

Maintaining energy balance by controlling appetite is a key strategy to prevent weight gain. In this regard, increased dietary protein has been shown an effective dietary strategy (Leidy, Carnell, Mattes, & Campbell, 2007; Westerterp-Plantenga, Nieuwenhuizen, Tomé, Soenen, & Westerterp, 2009).

As a considerable part of daily intake comes from snacking (approximately 25%) (Christensen, Fagt, & Trolle, 2012; Piernas & Popkin, 2010) it is relevant to study the effects of protein variation in products not just consumed at the typical main meals but in products also consumed as snacks. Snacking is defined as any eating occasion outside typical meal time (Christensen et al., 2012; Johnson & Anderson, 2010; Wansink, Payne, & Shimizu, 2010). Over the past 30 years, in addition to being a popular product consumed for breakfast, yoghurt has become a popular snack making the product relevant for appetite-reduction studies. The studies published to date which focus on variation in protein content in yoghurts, have demonstrated increased protein content as a potent modulator of short term appetite (Douglas, Ortinau, Hoertel, & Leidy, 2013; LLuch, Garsetti, L'Heureux-Bouron, Garry, & Lang, 2008).

The Norwegian dairy company TINE launched in January 2014 a yoghurt variant with increased protein content. The challenges were to produce a yoghurt variant that had greater appetite-reducing effect than an existing product and at the same time was accepted by consumers. As yoghurts often are consumed with a topping, each of the products was presented for consumers with two variants of muesli. To test the short-term appetite-reducing effect, the high-protein yoghurt w/mueslis were tested against normal-protein yoghurt w/mueslis. The hypothesis was that the yoghurt w/mueslis containing the highest amount of protein would reduce hunger significantly more and bring higher fullness immediately after intake and one hour post intake compared to the yoghurt w/mueslis containing the normal amount of protein. To rate acceptability, "food satisfaction" was used as response variable. Food satisfaction has previously been used as generalized appreciation of the food, incorporating a variety of situational aspects along with aspects related to the sensory food properties (Cardello, Schutz, Snow, & Leshner, 2000). Cardello and colleagues suggest "food satisfaction" as a more appropriate measure of consumers' response to foods than liking.

As previous research showed that study context affected hedonic ratings of food (Kennedy, Stewart-Knox, Mitchell, & Thurnham, 2004), the present study was conducted in two contexts; a lab context and a natural context, to study contextual differences on ratings of food satisfaction.

A laboratory are regarded the most controlled environment for testing (Lawless & Heymann, 2010), as the most environmental variables, stimulus variables and social interaction can be controlled by the experimenter. Consumers are believed primarily to focus on the food characteristics without being influenced by external variables. Thereby, a laboratory setting is very different from a real eating environment and the realism of the test location can be questioned. Food testing in consumer's homes is considered more optimal with regard to realism during consumption (Kennedy et al., 2004; McEwan, 1997, Lawless & Heymann, 2010). In such tests the products can be tested under normal conditions of use and consumption. However, with regard to snacks, not all snacks are consumed in consumers' home. Therefore, we conducted a natural-context study where consumers were asked to bring the product along and use it in a context, where it naturally would be consumed. Meiselman has pointed out this aspect in his call for "real foods to be tested by real people in a real dining situation" (Meiselman, 1992).

In the present study, consumers' appetite was studied pre-, immediately post and one hour post intake in the two contexts. Consumers in the natural context were hypothesised to rate hunger pre

intake higher than consumers in the lab context, as consumers in the natural context were expected to eat the product whenever hungry and not when dictated by the study. No contextual differences were expected on ratings of hunger, fullness and food satisfaction immediately post intake, and on ratings of hunger and food satisfaction one hour post intake.

The aims were: a) to study product effects on hunger, fullness and food satisfaction ratings immediately after intake and one hour after intake b) to study hunger, fullness and food satisfaction ratings differed between a lab context and a natural context

2. Method

The data from the lab study are a part of a larger dataset conducted for a study focusing on determinants to food satisfaction (to be published elsewhere).

2.1 Participants

A total of 239 consumers participated in the study. Of these, 107 consumers participated in a lab context at TINE's sensory laboratory facilities, Stavanger, Norway. Additionally 132 consumers were recruited for a similar study but conducted in a natural context. For both the lab- and natural context the recruitment was conducted among local associations around Stavanger, emphasising an even distribution of sex, age and educational level. Inclusion criteria were adult consumers of yoghurt w/muesli products; who liked yoghurts with muesli and were not working with food production, nor suffering from illness or food allergies. Participant characteristics can be seen in table 1.

Table 1. Participant characteristics in the lab context and natural context

	Lab study	Natural-context study
N	107	132
Gender (% male, % female)	37%, 63%	38%, 62%
Age (mean \pm std.)	44.7 \pm 10.4	36.9 \pm 15.4
n < 40 years, n \geq 40 years)	19.6%, 80.4%	45%, 55%
BMI (mean \pm std)	25.4 \pm 3.7	23.7 \pm 3.7
General liking of yoghurt w/muesli products^a	7.0 \pm 1.3	6.3 \pm 1.5
General attitude towards meals^a	7.0 \pm 1.3	6.6 \pm 1.3
General food liking^a	7.4 \pm 1,6	6.7 \pm 2.0
General attitude towards new foods^a	7.7 \pm 1.3	6.9 \pm 1.7

^a Measured on a 9 point hedonic scale

2.2 Experimental design/ study procedure

The lab- and the natural context study followed an incomplete design (see table 2), where two of four yoghurt w/ muesli product were consumed by each consumer, with one meal per day. Balance 1 to 4 was used approximately equal number of times in each context.

Table 2. Design balance used in lab study and natural-context study

	Day 1		Day 2	
	Yoghurt	Muesli	Yoghurt	Muesli
Balance 1	M	B	T	N
Balance 2	M	N	T	B
Balance 3	T	B	M	N
Balance 4	T	N	M	B

Prior to study start, consumers received instructions on how to conduct the test; oral instructions for consumers in the lab context and written instructions for consumers in the natural context. For the lab context, testing took part in sensory booths to minimize the inter-human effect on intake. In the natural context, testing took place at a time and in a place where eating a yoghurt w/ muesli product felt natural for the individual consumer in an everyday context. Products were provided blind in jars assigned a three digit random code; one containing muesli and yoghurt respectively. Consumers were instructed to pour the muesli onto the yoghurt and eat until they did not feel the desire to eat anymore. Ad libitum consumption was chosen rather than a fixed amount to make the intake as realistic as possible. In the lab context, if a portion was finished another serving was offered. Total intake was registered with a precision of 0.1 gram. In the natural context intake was estimated by consumers indicating amount eaten (cf. section 2.4). Consumers filled out three questionnaires relative to intake; one pre-, immediately post- and one hour post intake. In the one hour wait magazines and newspapers were provided to consumers in the lab context, whereas consumers in the natural context could continue with their everyday activities. In both contexts, Eye Question v 3.9. (Logic8, Wageningen, NL) was used for data collection of answers in questionnaires.

To thank consumers for completing the study, a fixed economic contribution was given to the associations where participants had membership.

2.3 Yoghurt w/muesli products

Test products were two variants of yoghurt (T, M) and two variants of muesli (B, N) served as combined products: MB, TN, MN and TB. Yoghurts and mueslis were prepared by TINE, Norway. Information about nutritional value of the four combined yoghurt w/ muesli products can be seen in table 3. Products containing yoghurt variant “T” was characterised by higher energy content than products containing yoghurt “M”. The differences were primarily due to higher protein content, but also a slightly higher fat content and slightly lower carbohydrate content. Muesli variant N was crunchy dominated by nuts and muesli variant B was crunchy dominated by berries. Yoghurts was portioned in jars of 150 grams and stored at 4 degrees Celsius. Muesli was portioned in jars of 20 grams and stored dark at 4 degrees Celsius.

Tabel 3. Product characteristics of yoghurt w/muesli products

	MB	TN	MN	TB
Energy content (kJ/100g)	416	499	420	495
Total protein (g)	5	10	5	10
Total fat (g)	3	4	3	4
Total carbohydrate (g)	11	10	12	9
Sugar (g)	7	6	8	5
Fibre (g)	2	1	1	1

2.4 Questionnaires

Three questionnaires were filled out by consumers; one pre-, immediately post- and one hour post intake. Pre intake consumers rated the response variables: perceived hunger and fullness status. Immediately post intake response variables included: perceived hunger, fullness and food satisfaction. For consumers in the natural context, the immediately post intake questionnaire further included a question about amount eaten. One hour post intake consumers rated the response

variables: perceived hunger and food satisfaction. The questionnaire one hour post intake further included questions about socio-demographics: gender, age, height, weight, educational level, frequency of consumption of yoghurt w/muesli products and the consumption context (only for the natural context), general liking of foods and yoghurt w/muesli products specifically and general attitude towards meals and new foods. Hunger, fullness and food satisfaction questions were worded as “do you feel ...” with end point anchors of “no, extremely not” and “yes, extremely” on a 9 point scale. Amount eaten was rated on the categorical scale: “all”, “almost all”, “a little more than half”, “a little”, “almost nothing” (only in natural context). Open response categories in the end of each questionnaire allowed consumers to express additional information.

2.5 Data and statistical analysis

Initially, height and weight were used to calculate BMI ($\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$). Summary statistics (sample means, standard deviations and standard error of mean) was computed for all continuous data.

Repeated measures mixed model ANOVA was performed to analyse within product differences in ratings of hunger: pre-, immediately post- and one hour post intake, fullness: pre- and immediately post intake and food satisfaction: immediately post- and one hour post intake.

To determine product main effects on hunger, fullness and food satisfaction, mixed model ANOVA was performed with subjects as random effect and followed by post hoc tests. In cases where significant product effects were found, the mixed model ANOVA was further used to study if differences could be allocated a muesli or yoghurt effect, and/or a muesli*yoghurt interaction.

Main effects of demographic data: gender, age, BMI, educational level and consumption frequency of yoghurt w/muesli products on hunger, fullness and food satisfaction variables was analysed using mixed model ANOVA with subjects as random effect and following post hoc. Consumers were divided into groups; gender with two levels: male and female, age with two levels; age ≥ 40 years and age < 40 years, BMI with four levels; underweight weight ($\text{BMI} < 18,5$), normal weight ($\text{BMI} 18,5-24,9$), over weight ($\text{BMI} 25-29,9$) and obese ($\text{BMI} \geq 30$), education with six levels: lower secondary, higher secondary, higher secondary with trainee, short-length higher education (≤ 2 years), medium-length higher education (two to four years), long higher education (> 4 years), and consumption frequency with five levels: \geq once a week, two-three times a month, once a month, one to five times every half year and $<$ once every half year. Interactions between each of the demographic variables and products were analysed.

To gain knowledge about the consumption context in the natural context the percent-wise distribution of answers related to: as which course, when, where and with whom the products were consumed were studied. Main effect of context variables on food satisfaction immediately post- and one hour post intake was studied performing mixed model ANOVA and following post hoc tests. Product effect on categorical data was analysed by chi-squared tests and following post hoc tests. All statistical analysis was conducted using R (R Core Team, 2014). For the mixed model analysis the R-packages *lme4* (Bates et al, 2014) and *lmerTest* (Kuznetsova et al., 2014) were used. All statistical tests were carried out with $\alpha = .05$.

3. Results

3.1 Intake

In the lab study total mean intake was: 138.6g, 144.7g, 135.9g and 142 g of product MB, MN, TB and TN respectively. No main product effect was found on mean intake (g). Mean energy content (kJ) and contribution from macro-nutrients, sugar and fibres can be seen in table 4. A main product yoghurt effect was found on energy intake ($p < .001$). Consumer's energy intake was significantly higher for intake of the high-protein products (TN, TB) than from the normal-protein products (MB, MN (all $p < .05$).

Tabel 4. Intake characteristics of yoghurt w/muesli products

	MB	TN	MN	TB
Energy content (kJ)	576	710	608	673
Total protein (g)	8	14	8	14
Total fat (g)	4	6	4	6
Total carbohydrate (g)	16	14	17	13
Sugar (g)	10	8	11	7
Fibre (g)	2	1	1	2

In the natural context, the percentage of consumers estimated to have eaten all/almost the entire product was: 58.5%, 56.7%, 53.7% and 56.9% for product MB, MN, TB and TN respectively. The percentage who estimated to have eaten around half of the product (“slightly less than half” to “slightly more than half” are pooled) was: 26.2%, 22.4%, 28.4% and 27.7% for product MB, MN, TB and TN respectively. No product effect on intake was found.

3.2 Hunger and fullness

Figure 1 illustrates rated hunger pre-, immediately post- and one hour post intake in the two contexts. Regardless of context all meals led to reductions in hunger immediately post intake (all $p < .05$), a reduction which was sustained one hour post intake (all $p_{\text{pre vs. one hour}} < .05$, all $p_{\text{immediately post vs one hour}} > .05$ except for TN_{lab} where $p_{\text{immediately post vs one hour}} < .0001$). Hunger ratings did not differ between products in either of the two study contexts pre-, immediately post- and one hour post intake.

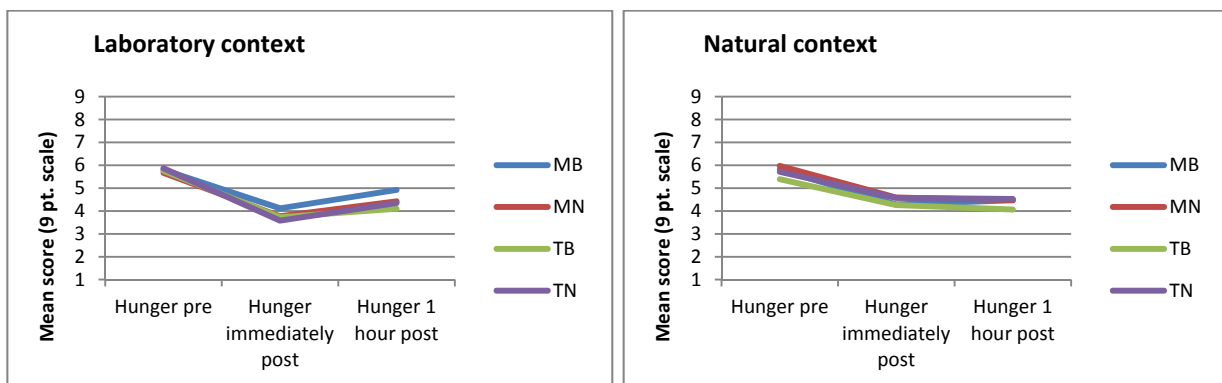


Figure 1. Mean hunger ratings pre-, immediately post and one hour post intake for product Mb, MN, TB and TN respectively. To the left: laboratory context, to the right: natural context

Regardless of context all products led to increased perceived fullness post intake (all $p < .05$). A significant main product effect was seen for post intake fullness ($p = .04$) in the lab context, not in the natural context. Differences in fullness were significant between products MB vs. TN ($p = .007$) and MN vs. TN ($p = .041$). Results showed that differences in fullness could be regarded a yoghurt effect ($p_{\text{fullness immediately post intake}} = .024$). No yoghurt*muesli interaction effects were found. Mean intake fullness ratings can be seen in figure 2.

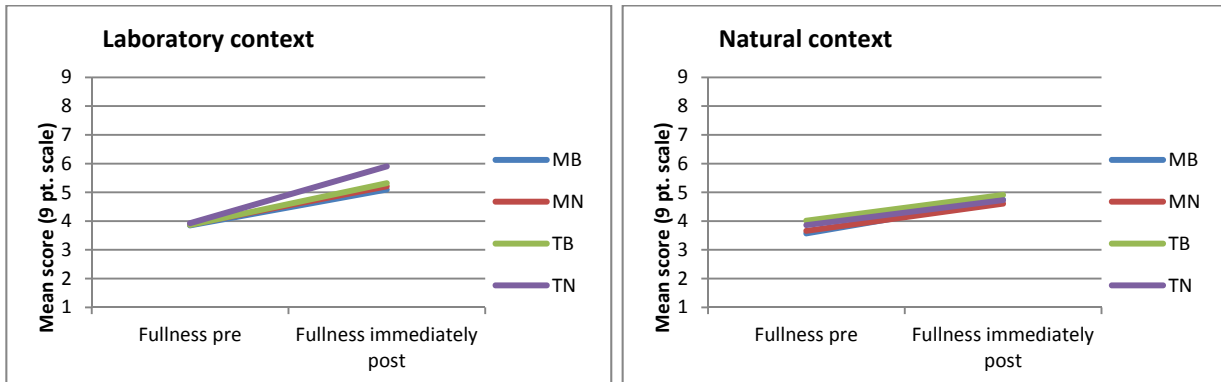


Figure 2. Mean fullness ratings pre- and immediately post intake for product Mb, MN, TB and TN respectively. To the left: laboratory context, to the right: natural context

3.3 Food satisfaction

In the lab context a significant main product effect was seen for immediately post intake ratings of food satisfaction ($p = .009$), and food satisfaction one hour post intake ($p = .03$). Post hoc test showed significant differences in satisfaction between product MB vs. TN ($p_{\text{satisfaction immediately post intake}} = .009$ and $p_{\text{satisfaction one hour post intake}} = .03$) and MN vs. TB ($p_{\text{satisfaction immediately post intake}} = .027$ and $p_{\text{satisfaction one hour post intake}} = .04$). Results showed that differences in food satisfaction could be regarded a muesli effect ($p_{\text{satisfaction immediately post intake}} = .0008$ and $p_{\text{satisfaction one hour post intake}} = .003$). No yoghurt*muesli interaction effects were found. No effect of product on ratings of immediately post- and one hour post intake food satisfaction was found in the natural-context study. Mean food satisfaction scores can be seen in figure 3. Within-product food satisfaction ratings (immediately post- and one hour post intake) did not differ in either of the two contexts.

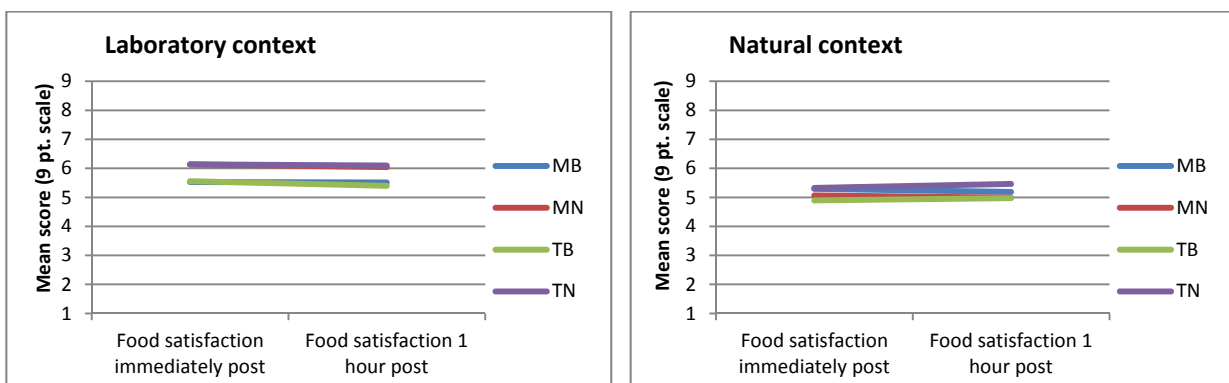


Figure 3. Mean food satisfaction ratings immediately post- and one hour post intake for product Mb, MN, TB and TN respectively. To the left: laboratory context, to the right: natural context

3.4 Demographic data

Main effects of demographic data: gender, age, BMI, educational level and consumption frequency of yoghurt w/ muesli products on hunger and food satisfaction ratings were studied in both contexts. In the lab study no main effect of either of the demographic data was found on hunger ratings immediately post- and one hour post intake. A main effect of BMI was found on food satisfaction immediately post- and one hour post intake ($p_{\text{immediately post intake}} = .01$, $p_{\text{one hour post intake}} = .005$). In general it was found, that consumers with higher BMI gave lower ratings of food satisfaction (same tendency for immediately post- and one hour post intake ratings). Further, a main effect of consumption frequency on food satisfaction immediately post- and one hour post intake was found ($p_{\text{immediately post intake}} = .015$, $p_{\text{one hour post intake}} < .001$). The more frequent yoghurt w/muesli was consumed, the higher ratings of food satisfaction (same tendency for immediately post- and one hour post intake scores). No main effect of gender, age and education was found on food satisfaction. No interaction among demographic variables and product was found.

In the natural context a main effect of age (immediately post intake: $p_{\text{satisfaction}} = .002$, $p_{\text{hunger}} = .010$, $p_{\text{stomach fullness}} = .015$, one hour post intake: $p_{\text{hunger}} = .001$, $p_{\text{satisfaction}} = .006$), BMI (immediately post intake: $p_{\text{satisfaction}} = .004$, $p_{\text{hunger}} = .045$, one hour post intake: $p_{\text{satisfaction}} = .001$) and educational level (food satisfaction: $p_{\text{post intake}} = .005$, $p_{\text{one hour postintake}} < .001$) was found, whereas no main effect of gender and consumption frequency were found. In general the oldest age group was more satisfied and less hungry than the youngest age group. Fullness and food satisfaction increased with increasing BMI, except for obese whose mean scores were intermediate (same tendency for post- and one hour post intake scores). Under- and normal weight consumers scored hunger higher than overweight and obese (same tendency for immediately post- and one hour post intake scores). Food satisfaction was found to increase with increasing educational level, except for “medium-length higher education” whose scores were intermediate (same tendency for immediately post- and one hour post intake scores). No interaction among demographic variables and product was found.

3.5 Effects of study context

Pre intake ratings of hunger and fullness were not significantly different between lab- and natural context. A main effect of study context was seen for immediately post intake ratings of hunger ($p = .002$), fullness ($p = .0023$) and food satisfaction ($p = .0034$) and one hour post intake ratings of food satisfaction ($p = .015$). In the natural context, consumers gave higher ratings of hunger ($\text{mean}_{\text{diff}} = .6$), lower rating of fullness ($\text{mean}_{\text{diff}} = .6$) and lower ratings of food satisfaction immediately post and one hour post intake ($\text{mean}_{\text{diff}} \text{ satisfaction immediately post} = .4$, $\text{mean}_{\text{diff}} \text{ satisfaction one hour post} = .6$). Mean values can be seen in figure 4. One hour post intake ratings of hunger were not significantly different between contexts.

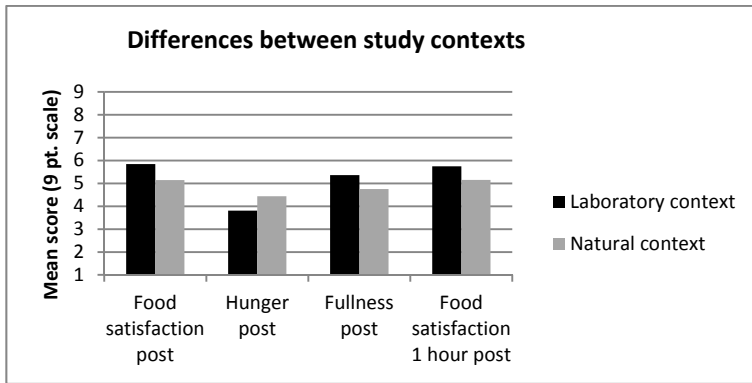


Figure 4. Mean immediately post intake ratings of food satisfaction, hunger and fullness and food satisfaction one hour post intake depending on study context

3.6 Consumption context in natural context

The context in which the consumption took place was studied by asking: as which course, when, where and with whom the products were consumed. 28%, of consumers consumed the products as a late dinner. 24.2%, 23.5% and 20.5% of consumers consumed the product as a lunch, breakfast and snack respectively, whereas 3,8% reported to consume the product as an early dinner.

The majority, 80.7%, reported the time to previous meal to be more than two hour. 13.3% had been eating one to two hours before, and 6% of consumers less than one hour before.

Consumers most often consumed the product at home, 79.2%. 14% consumed the product at the job or school 14%, 5.3% on-the-go, 0.4% at a social arrangement and 1.1 % in another context (e.g. sport facility).

55.1% consumed the product alone, 35% with family, 7.6% with colleagues and 2.3% with friends. Of the context variables rated, a main effect was seen for whom consumers consumed the product with on ratings of food satisfaction immediately post- and one hour post intake, not for hunger. One hour post intake mean values of food satisfaction were generally higher when consuming products among others than alone (mean_{alone} 5.2, mean_{colleagues} 5.7, mean_{family} 6.0 and mean_{friends} 6.1). The same tendency was seen for food satisfaction post intake, with an exception of eating with family which reflected lowest mean ratings (mean_{alone} 5.2, mean_{colleagues} 6.0, mean_{family} 4.9 and mean_{friends} 5.4).

4. Discussion

One of the aims of this study was to compare the short term appetite-reducing effect of high-protein yoghurt w/muesli products compared to normal-protein yoghurt w/ muesli products. In contrast to what was expected, the results showed no differences between products in hunger immediately post- and one hour post intake indicating that the higher protein content did not have an additional effect on satiation and satiety. The lack of differences observed in this study might be due to the relative small differences in protein content between products. Recall that difference between the high-protein products and normal-protein products were 6 grams (table 4). Similar results were found by Ortinau and colleagues, reporting no difference in hunger and fullness following intake of a high-protein yoghurt (14g) and a low-protein yoghurt (5g) (Ortinau, Culp, Hoertel, Douglas, & Leidy, 2013). In a study by Douglas and colleagues yoghurt with three levels of protein was used; low (5g), moderate (14g) and high (24g) (Douglas et al., 2013). They found significant lower hunger ratings following intake of the high-protein yoghurt compared to the low protein yoghurt, but no difference between the low-protein and moderate-protein yoghurts. These studies support the

assumption that the small differences in protein content might be related to the lack of differences in hunger ratings.

As expected, a significant yoghurt effect was found for perceived fullness, with the high-protein products rated higher than to the low-protein products (only significantly higher fullness for TN and only in the lab study). However, it can be questioned if the increased perceived fullness only was due to protein effects. Analysis of intake showed that the high-protein products were associated with higher total energy content which might also have affected fullness perceptions. Further, the sensory properties could have affected fullness ratings. Increased protein content have been associated with higher thickness and texture (LLuch et al., 2008), and previous studies have shown thickness and viscosity to positively influence expectations of satiating properties (Brunstrom, Shakeshaft, & Scott-Samuel, 2008), satiation and appetite reduction (Lavin, French, Ruxton, & Read, 2002; Zijlstra, Mars, de Wijk, Westerterp-Plantenga, & de Graaf, 2008). Sensory differences between products were however out of the scope for this paper.

A second aim of this study was to compare food satisfaction between products. Results showed that differences in food satisfaction ratings was due to a muesli effect, with the products containing the muesli dominated by nuts rated more satisfying than the products containing mueslis dominated by berries. The fact that differences in food satisfaction only were found in the lab context can reflect that consumers' focus on the product was different in the two studies. In the lab study, consumers are believed to have increased focus on the sensory product characteristics, whereas in the natural-context, especially the social eating environment could have diverted consumers' attention to the product characteristics. However, no measures could support this hypothesis.

In contrast to expected, pre intake ratings of hunger did not differ between the lab- and the natural context. A main context effect was found for immediately post intake ratings of hunger, fullness and food satisfaction, and one hour post intake ratings of food satisfaction. Overall, consumers in the natural context gave higher hunger ratings, lower fullness ratings and lower food satisfaction ratings compared to consumers in the lab context. The differences in hunger and fullness ratings could be caused by a general lower intake of yoghurt w/muesli among consumers participating in the natural context. However, as different methods were used for registration of intake, a direct comparison was not possible. The effect of study context on hedonic ratings of food have been investigated previously (Kennedy et al., 2004; Pound, Duizer, & McDowell, 2000) showing mixed results. While Pound and colleagues found no effect of study context on overall liking of chocolates, Kennedy and colleagues found higher ratings of overall liking of chicken when evaluated at home compared to when evaluated in laboratory. Though the consumers participating in the present lab context and the natural context were recruited based on the same criteria, consumers in the lab context were slightly more positive towards food in general than consumers in the natural context (table 1). These results indicate that the contextual differences found on food satisfaction, could be due a general different attitude towards foods in the two contexts. To avoid this, the same consumers should have used in both contexts or their general attitude towards foods should have been equal. Nevertheless, the context-related differences reported in our study highlight that the study context should be considered carefully when conducting consumer tests, as the context might lead to different conclusions about a product.

The ad libitum intake used in the present study can be regarded a strength as well as a weakness of the study. The advantage of an ad libitum study is that the results are based on an intake which is realistic among consumers of yoghurt w/muesli products. However, the ad libitum design resulted

in differences in total energy intake among products (no differences in intake in grams), which might have affected the fullness and hunger results. A way to overcome this problem would be to use forced intake of a fixed iso-energetic amount of each product, a strategy used in several other studies investigating the effect of protein content in yoghurts (Douglas et al., 2013; Ortinau et al., 2013). Important to keep in mind in this regard is further to use similar mass and volume as greater mass and volume in itself can reduce appetite (see reviews (Rolls, 2009; Welch, 2011)). Though, it would have been an advantage for the interpretation of results if energy content, mass and volume had been match between products, such a study would lack the realism as all consumers cannot be expected to naturally eat the amount dictated by the study. Therefore, strength and weaknesses exists for both ad libitum and fixed intake designs and neither can be chosen without compromising either interpretability or realism.

To gain knowledge about the products effect on energy intake in following meals, a pre-load study could be conducted. A pre-load study would clarify, if the high-protein products despite their higher total energy content could cause long-term lower energy intake. Pre-loads was used in three studies investigating the effect of protein on appetite-reduction in yoghurts (Douglas et al., 2013; Lluch et al., 2010; Ortinau et al., 2013). Douglas and colleagues found no difference in intake following preload of low, moderate and high protein yoghurts (Douglas et al., 2013). Ortinau and colleagues likewise did not find an effect following normal vs. high protein-preloads (Ortinau et al., 2013). A significant effect was found by Lluch et al (2010), who reported decreased energy intake following a high-protein preload compared to a control. However, the high-protein product was further related to an increased fiber intake, which also could have caused the following lower energy intake.

5. Conclusion

In conclusion, the study showed significant differences in food satisfaction between four yoghurt w/muesli products, with two levels of protein/energy content and two variants of muesli. Differences in food satisfaction were demonstrated due to a muesli effect, not yoghurt effect, with the products containing muesli dominated by nuts rated higher in food satisfaction than the products containing muesli dominated by berries. These findings indicate that the appreciation of the muesli might overrule the appreciation of the yoghurt, but further studies would have to clarify this. The differences found on food satisfaction were only present in a lab context, not in a natural context. No differences in immediately post intake- and one hour post intake ratings of hunger following intake was found between products in either of the contexts. Fullness rating was significantly higher for the high-protein products than the normal-protein products, but only in the lab context. Fullness ratings were found due to a yoghurt effect. In general the study design used in this study makes interpretation of the effect of protein content on hunger and fullness ratings difficult, as the results do not only reflect differences in protein content but also in energy intake and sensory perceptions. An effect of context (lab- vs. natural context) was found for immediately post intake ratings of hunger, fullness and food satisfaction, and one hour post intake ratings of food satisfaction. Overall, the differences indicate that it takes more of a product to reduce appetite and increase satisfaction in a natural context, than it does in a lab context. However, background data indicate that differences could be due a general different attitude towards foods among consumers in the two contexts.

Acknowledgements

This study is a part of the Senswell project funded by Innovation Fund Denmark (grant no. 0603-00418B). TINE kindly provided products for this study.

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PIV

Peri- and post intake drivers of satisfaction with yoghurt with/muesli products

Barbara Vad Andersen^{a*}, Hilde Kraggerud^b, Per Bruun Brockhoff^c & Grethe Hyldig^a

^a*National Food Institute, Department of Industrial Food Research, DTU, Soeltofts Plads, Building 221, DK-2800 Kgs. Lyngby, Denmark*

^b*TINE R&D Ctr, N-4068 Stavanger, Norway*

^c*DTU Compute, Danish Technical University, Matematiktorvet, Building 324, DK-2800 Kgs. Lyngby, Denmark*

**Corresponding author. E-mail address: bvan@food.dtu.dk Phone: 0045 45252548.*

Abstract

The primary aim of this study was to determine the variables mainly influencing satisfaction immediately after intake and one hour post intake. In a consumer study involving 107 consumers, subjects consumed and evaluated yoghurt with muesli products. Four products were used by combining two variants of yoghurt and two variants of muesli.

Consumers evaluated products based on questionnaires including questions related to sensory satisfaction, physical- and psychological wellbeing sensations, food satisfaction and socio demographics.

Variables highly influential for food satisfaction immediately after intake included: sensory satisfaction, product performance relative to expectations, reason for ending intake and general liking of yoghurt w/muesli products. Variables highly influential for food satisfaction one hour post intake included: memory of sensory satisfaction, experiencing pleasant energy level and stomach feelings, BMI status, consumption frequency and general liking of yoghurt w/muesli products.

Together these result show sensory properties to have a prominent role in food satisfaction, but also that physical well-being related sensations and demographics contribute to satisfaction.

As sensory satisfaction was found highly influential in food satisfaction, sensory differences between products were studied and related to consumers rating of sensory satisfaction. Analysis of sensory- and consumer data showed that muesli differences dominated the sensory perceptions and consumer hedonic scores.

1. Introduction

Studies on hedonic appreciation of food have to a large extent focused on the sensory food properties, and consumer's acceptance of those. This is with good course, as the sensory food properties play a very important role in the way we select our food and how much we consume (Sørensen, Møller, Flint, Martens, & Raben, 2003). One of the most common measures of consumer acceptance is measures of food liking/disliking (A. V Cardello, Schutz, Snow, & Leshner, 2000). However, as sensory characteristics are not the only perceptions experienced in relation to food intake it can be questioned if meeting consumers sensory needs and desires only can guarantee for long-term product success. During and after food intake physiological processes are involved in the eating processes and can affect consumer appreciation of the food eaten as well (Kringelbach, Stein, & van Hartevelt, 2012; Yeomans, 2010). The physiological aspects relate to the post – ingestive and post – absorptive processes resulting in satiation and satiety and overall physiological- and psychological well-being. Boelsma and colleagues hypothesised that postprandial wellness, a measure defined as the subjective appreciation of food after intake, combining physiological and psychological sensations resulting from the food intake process, may help to clarify the mechanisms of food intake, consumer satisfaction and longer term food consumption (Boelsma, Brink, Stafleu, & Hendriks, 2010). In the present paper we support this view and argue that the drivers behind our hedonic appreciation of foods should be seen as a combination of sensory perceptions and perceptions of the physical- and psychological food related sensations.

This way of seeing the hedonic food experience, may well require new and more appropriate measures of consumer's response to foods. Cardellos and colleagues suggest "satisfaction", a term commonly used within marketing, to be a better measure than the well-known measure of liking/disliking (A. V Cardello et al., 2000). Where liking/disliking focuses on the hedonic aspects of the food itself satisfaction can be regarded a broader term implying a generalized appreciation of the food. Cardello and colleagues hypothesise that "satisfaction" might imply something about the food's value, it's utility or its adequacy for the situation (A. V Cardello et al., 2000). They showed that satisfaction was better predicted by pre- and post-test variables than were either liking/disliking or consumption measures.

In the present study we use two satisfaction-terms; sensory satisfaction and food satisfaction. Sensory satisfaction should be regarded a generalised measure of subject's hedonic appreciation of the foods sensory properties, as when measuring sensory satisfaction consumers are asked to rate satisfaction with the foods appearance, odour, taste and texture altogether. Food satisfaction implies a generalised appreciation of the food including food related feelings of physical- and psychological wellbeing after intake (tjek at det passer med definition).

This new way of seeing the hedonic food experience may, in relation to using new measures, also require reconsidering the time point at which we measure the hedonic food experience. Measures of liking/disliking are traditionally conducted during intake. At this time point the physiological and psychological effects of the food are not fully perceived. As these processes also relate to the post-ingestive and post-absorptive processes, we suggest, measures of food satisfaction to be collected after intake.

The present study focused on measuring consumers' satisfaction with foods immediately- and one hour after intake. Satisfaction was believed related to the general rewarding properties of food intake happening during the food intake cycle (Kringelbach et al., 2012) including sensory perceptions and feelings of physical- and psychological wellbeing. It was hypothesised that sensory satisfaction was highly influential in food satisfaction immediately after intake whereas physical sensations influenced food satisfaction one hour after intake the most.

As study matrice, yoghurt naturel w/ muesli products were chosen. Yoghurts are popular products consumed both as main meals and snacks, making them relevant as study matrices (Douglas, Ortinau, Hoertel, & Leidy, 2013; Ortinau, Culp, Hoertel, Douglas, & Leidy, 2013). In Norway the per capita consumption of yoghurt in 2013 was 11.3 kg (Opplysningskontoret for Meieriprodukter, Melk.no).

The objective was to find variables primarily influencing satisfaction with yoghurt w/muesli products immediately after- and one hour after intake, and study the role of sensory perceptions compared to physical and psychological well-being sensations. Further, as combined products (yoghurts w/muesli) were used, it was relevant to study, if potential product differences could be regarded yoghurt, muesli or interaction effects.

2. Materials and methods

2.1 Products

Four commercial yoghurt-muesli combinations were analysed; MB, MN, TB, TN, consisting of two variants of yoghurt (M, T) and two variants of muesli (B, N). Energy content varied between yoghurt variants, mainly due to differences in protein content, with variant T being more energy dense and protein rich than M. Energy content of muesli B (dominated by berries) and N (dominated by nuts) did not differ remarkable. Energy content (kJ/100g) for the four products was: 416 (MB), 420 (MN), 495 (TB) and 499 (TN), and protein content: 5g/100g (MB), 5g/100g (MN), 10g/100g (TB) and 10g/100g(TN). The samples were produced by the Norwegian dairy company TINE and the combinations selected specially for the study.

2.2 Consumer study

A total of 107 consumers participated in the study. Each consumer evaluated two of the four products; either MB and TN or MN and TB, indicating two consumers segments in the study; segment a and b respectively. Participant characteristics can be seen in table 1.

Testing took place in sensory booths to minimize the inter-human effect on evaluation. Products were provided blind in jars assigned a three digit random code; one containing muesli and yoghurt respectively. Products were served at 4°C. Consumers were instructed to pour the muesli onto the yoghurt and eat the product ad libitum, until they did not feel the desire to eat anymore. If a portion was finished another serving was offered.

Table 1. Participant characteristics; overall and in segment a and b respectively

	Overall	Segment a	Segment b
N	107	53	54
Gender male, female	♂37%,♀63%	♂34%,♀66%	♂41%,♀59%
Age mean (min, max)	44.7 (18, 75)	44.5 (18, 75)	44.9 (20, 65)
Education ^a	0%, 18.7%, 8.4%, 5.6%, 30.8%, 36.4%	0%, 19.2%, 3.8%, 5.8%, 25%, 46.2%	0%, 18.5%, 13%, 5.6%, 35.2%, 27.5%
BMI	25.4 (± 3.7)	24.6 (± 3.2)	26.3 (± 4.0)
Frequency of yoghurt w/muesli consumption ^c	54.7% 30.2%, 5.7%, 9.4%	63.6%, 27.3%, 5.5%, 3.6%	59.3%, 28.7%, 5.6%, 6.5%
General liking of yoghurt w/muesli products ^b	7.0 (± 1.3)	7.1 (± 1.5)	7.0 (± 1.2)
General attitude towards meals ^b	7.0 (± 1.3)	7.1 (± 1.2)	7.0 (± 1.4)
General food liking ^b	7.4 (± 1.6)	7.2 (± 1.8)	7.7 (± 1.3)

General attitude towards new foods ^b	7.7 (± 1.3)	7.6 (± 1.4)	7.8 (± 1.1)
General desire to other foods after meals ^b	5.0 (± 2.0)	5.0 (± 1.8)	5.0 (± 2.2)

^a lower secondary, higher secondary, higher secondary with trainee, short-length higher education (\leq two years), medium-length higher education (two to four years), long higher education ($>$ four years)

^b mean(± std.) measured on a 9-point scale

^c \geq once a week, two-three times a month, once a month, one to five times every half year

Consumers filled out four questionnaires relative to intake; one pre-, peri-, post- and one hour post intake. Variables included in the respective questionnaires can be seen from table 2. Continuous variables followed the form “do you feel ...” and measured on a 9 point scale with end point anchors of “no, extremely not” and “yes, extremely”, and a middle point of “neither/nor”. Categorical variables included: Reason for ending meal (categories: satiation, sensory boredom, unpleasantness, conscious and other reason), product performance relative to expectation (categories: worse, as expected, better), desire for other foods (categories: yes, no), gender (categories: male, female), education (categories: lower secondary, higher secondary, higher secondary with trainee, short-length higher education, medium-length higher education, long higher education) and consumption frequency (categories: \geq once a week, two-three times a month, once a month, one to five times every half year). Variables with open response categories included: age, height and weight. Open response categories in the end of each questionnaire allowed consumers to express additional information. EyeQuestion v 3.9. (Logic8, Wageningen, NL) was used for direct data collection. To thank consumers for completing the test, a fixed economic contribution was given to the associations where participants had membership.

Table 2. Variables included in questionnaires

Pre intake variables	Peri intake variables	Immediately post intake variables	1 hour post intake variables	Socio variables
Hunger	Liking of appearance	Food satisfaction	Food satisfaction	Gender
Fullness	Liking of odour	Reason for ending meal	Memory of sensory satisfaction	Age
Physical well-being	Liking of taste	Hunger	Desire for other foods	Height
Psychological well-being	Liking of texture	Fullness	Hunger	Weight
Expected liking	Sensory satisfaction	Product performance relative to expectations	Energy	Education
Desire to eat		Desire to eat again	Pleasant stomach feelings	Consumptions frequency
Appropriateness		Physical well-being		General liking of yoghurt w/muesli
		Psychological well-being		Attitude towards new foods
		Desire for other foods		
		Fulfilment of expectations		

2.3 Statistical analysis of consumer data

Initially, height and weight were used to calculate BMI ($\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$). Mean and standard deviation for each variable for each product was then calculated.

To study if the two consumer groups differed in ratings of the products, a main effect of segment on pre-, during-, post- and one hour post intake variables was studied. As no effect was found (see section 3.1) all further analysis was conducted regarding consumers as one group.

Repeated measures mixed model ANOVA was applied to analyse within product differences from pre- to post intake.

To obtain information about products effects on pre-, during-, post- and one hour post intake variables mixed model ANOVA was conducted with subjects as random effect. For variables where significant product effect was found mixed model ANOVA was further used to study if significant differences between products could be regarded a main yoghurt- or muesli effect, or a yoghurt*muesli interaction. All statistical analysis was conducted using R (R Core Team, 2014). For the mixed model analysis the R-packages *lme4* (Bates et al, 2014) and *lmerTest* (Kuznetsova et al., 2014) were used.

To study drivers of food satisfaction immediately- and one hour post intake, two Partial Least Square regression (PLSR) was applied; one using food satisfaction immediately after intake as Y-variable and selected variables peri- and immediately post intake variables and demographic data as X-variables, and a second using food satisfaction one hour post intake as Y-variable and one hour post intake variables and demographic data as X-variables. Data were centered and auto-scaled. Variable selection was based on Variables Important in Projection (VIP) which summarises the importance of the X-variables for both the X- and Y-models. A VIP score of 0.8 was used as cut-off value (Wold, 1995; Eriksson et al, 2001). A $1 > VIP > 0.8$ was regarded moderately influential and $VIP > 1$ highly influential. PLSR was run across products and included raw consumer data. PCA of influential variables from PLSR was used to visualise correlations. Data analysis was performed using XLSTAT (version 2014.3, addinsoft S.A.R.L.).

2.4 Sensory analysis of products

As sensory satisfaction was regarded a significant driver of satisfaction one hour post intake (ref. section 3.1.2), sensory differences among products were studied. Sensory profiling of products was conducted in a sensory lab with a tested and trained panel following the ISO standards. Yoghurts was portioned in jars of 150 grams, stored and served at 4 °C. Muesli was portioned in jars of 20 grams, stored dark at 4 °C and served at 4°C.

Before conducting the sensory profiling test, assessors were instructed to pour the muesli on top of the yoghurt and evaluate spoonful's consisting of both muesli and yoghurt. By following this procedure the products were presented the same way in the sensory and the consumer test.

For descriptor selection an 8-member trained sensory panel at the National Food Institute, the Danish Technical University was used (five female/ three male). The members of the panel were all experienced with using the sensory profile method, having three to 16 years of experience as panel members.

In four sessions of two hours duration the panel was trained using comparable products. During the training sessions, the panel developed a vocabulary of sensory descriptors through discussion and selection of the most suitable attributes. Further, the panel decided on an evaluation procedure. The final vocabulary composed 20 attributes describing appearance (at serving time and after three minutes), odour, flavour and texture (at serving time and after three minutes) (table 3). The intensity of each attribute was determined using a 15 cm unstructured line scale with the anchor points "little" and "much".

The yoghurt w/muesli products were evaluated in triplicates in random order on two different days. Ratings were registered on a direct computerized registration system (Biosystemes, Fizz software Acquisition 2.47). An hour-glass lasting three minutes was used in standardised way to ensure that the panel evaluated the samples at equal time intervals.

Table 3. Definition of descriptors used in the sensory profile and time of evaluation

Attribute	Definition	Time of evaluation
Appearance		
Brightness	Bright surface	serving time
Solidity	Speed of fall of the product	serving time
Colour set off	Colour set off from muesli to yoghurt	after three minutes
Intact muesli	Intact lumps of muesli	after three minutes
Odour		
Lactic acid	Lactic acid	serving time
Sweetness	Elemental sweetness	serving time
Berries	Mixed berries	serving time
Dusty	Granary, cardboard	serving time
Grains	Oat	serving time
Nuts	Hazelnut, almond	serving time
Caramelised	Aromatic sweet sensation typical of the burnt sugar	serving time
Flavour		
Sweetness	Sweet	serving time
Caramelised	Aromatic sweet sensation typical of the burnt sugar	serving time
Berries	Mixed berries	serving time
Lactic acid	Lactic acid	serving time
Grains	Oat	serving time
Nuts	Hazelnut, almond	serving time
Texture		
Astringency	Dry mouthfeel	serving time
Crispiness	Crunchy	serving time
Crispiness	Crunchy	after three minutes

2.5 Statistical analysis of sensory data

Three-way analysis of variance (ANOVA) was applied to profiling data to study attributes that significantly discriminated products. Assessors and replicates and their interaction were treated as random effect.

Principal component Analysis (PCA) was applied to mean values of attribute intensities to study attributes that characterised each product. For analysis of profiling data Panel Check (version 1.4.0, Nofima Mat, Ås, Norway) was used.

Mixed model ANOVA was applied to attributes that significantly discriminated the products to study if significant effect could be regarded a main: yoghurt, muesli or a yoghurt*muesli interaction effect. For these analyses the R-packages *lme4* (Bates et al, 2014) and *lmerTest* (Kuznetsova et al., 2014) were used. For all analysis significance level was set to $\alpha = .05$.

3. Results and discussion

3.1 Consumer study

As can be seen from the participant characteristics in table 1, the two segments of consumers were relative similar. The segments differed by segment b having: more male subjects, more subjects in educational group 3 and 5 and fewer in group 6, slightly higher BMI, fewer consumers reporting to consume yoghurt w/muesli products \geq one a week and higher ratings of general food liking.

As the two segments did not differ in ratings of any of the pre-, during-, post- and one hour post intake variables, consumers were treated as one group in all subsequent analysis.

3.1.1 Pre-, during-, post- and one hour post intake product differences

Regardless of product, all meals caused decreased hunger following intake (all $p < .05$) and increased the feeling of fullness (all $p < .05$). Further, all meals increased physical- and psychological wellbeing (pre- vs. post intake comparisons), however the difference was only significant for product TN ($p = .03$). The effect on physical- and psychological wellbeing are probably related to the general rewarding properties of food intake happening during the food intake cycle (Kringelbach et al., 2012). The effect on psychological well-being can be related to the positive effect of food intake on mood found by Benton et al (2001) and Lloyed et al (1996), though e.g. cognition could be related to the effect as well.

Table 4 show between-product differences, and whether differences between products could be regarded a main yoghurt or muesli effect or a yoghurt*muesli interaction.

No product differences were seen for pre-intake variables except for physical wellbeing where consumers reported increased physical wellbeing before intake of product TN compared to MB. Product TB and MN was intermediate.

For peri-intake variables, consumer did not show difference in liking of appearance and odour between products. Consumers liked the taste and texture of the nut-containing yoghurt w/muesli products better than the berry-containing yoghurt w/muesli products. For sensory satisfaction nut containing products were also rated higher than berry-containing. Significant differences were found between product MB and TN, while MN and TB was intermediate. Mean, standard deviations and significant product differences for during intake variables are clarified in table 5. ANOVA-lmer showed that the product effect was due to a muesli effect as significant main muesli effects for liking of taste and texture, and sensory satisfaction were found (table 4). The effects could not be regarded a main yoghurt effect or yoghurt*muesli interaction effect.

Post intake, significant product effects were found for: food satisfaction, fulfilment of expectations, fullness and desire to eat again (table 4). And one hour post intake a significant product effect was found for food satisfaction and memory of sensory satisfaction. ANOVA-lmer showed that all significant product effects could be regarded muesli effects except for fullness, which could be regarded a yoghurt effect. No yoghurt*muesli interactions were found. Mean, standard deviations and significant product differences are shown in table 6, for variables where significant product differences was found.

Fullness ratings were significantly higher following intake of the energy dense/ protein rich products. This finding is supported by other studies indicating reduced appetite following intake of protein rich products compared to products low in protein (Douglas et al., 2013; Lluch et al., 2010). Despite the differences found for fullness, no differences between products were found for hunger ratings post intake. A reason for this, also suggested by other studies, may be the relative small differences in protein content between products (Douglas et al., 2013; Ortinau et al., 2013). In general, protein content in food is a well-documented strong determinant for short-term satiety (Anderson & Moore, 2004; Halton & Hu, 2004).

Significant differences were found for “desire to eat again” (between MB and TN). “Desire to eat again” reflect a cognitive element which is based on the learning process taking place throughout the intake cycle (Kringelbach et al., 2012), where all experiences are evaluated (often subconsciously) and can affect future actions. The fact that a significant difference only was found

between MB and TN reflect well that consumers base their desire on sensory perceptions as well as physical- and psychological sensations. Do however note that multiple factors often independent of the food itself will influence whether the product will be chosen for consumption prospectively (Thomson, D.M.H., 1988; Meiselman, H.L., 2007). Therefore, high ratings of “desire to eat again” can only be interpret as a guidance of future selection.

Table 4. *F*-ration and corresponding p-values ($\alpha = .05$) for main product, yogurt and muesli effect, and yoghurt*muesli interaction effect on pre-, during-, post- and one hour post intake variables in consumer study

Variable	Product		Yoghurt		Muesli		Y*M	
	F	P-val.	F	P-val.	F	P-val.	F	P-val.
Pre intake								
Hunger	.170	NS	-	-	-	-	-	-
Fullness	.058	NS	-	-	-	-	-	-
Physical wellbeing	3.440	.019	-	-	-	-	-	-
Psychological wellbeing	1.03	NS	-	-	-	-	-	-
Expected liking	.719	NS	-	-	-	-	-	-
Desire	.995	NS	-	-	-	-	-	-
Appropriateness	1.059	NS	-	-	-	-	-	-
During intake								
Liking appearance	1.416	NS	-	-	-	-	-	-
Liking odour	.077	NS	-	-	-	-	-	-
Liking taste	3.135	.028	1.163	NS	8.096	.005	.011	NS
Liking texture	3.043	.031	.616	NS	8.65	.005	.149	NS
Sensory Satisfaction	3.859	.011	.319	NS	11.265	.001	.000	NS
Post intake								
Satisfaction	4.052	.009	.089	NS	12.06	.001	.008	NS
Fulfilment of expectations	4.902	.003	.001	NS	14.697	.000	.013	NS
Hunger	1.416	NS	-	-	-	-	-	-
Fullness	2.870	.038	5.241	.024	2.675	NS	.859	NS
Desire to eat again	6.194	.001	.125	NS	18.318	.000	.164	NS
Physical wellbeing	4.403	.006*	-	-	-	-	-	-
Psychological wellbeing	1.019	NS	-	-	-	-	-	-
One hour post intake								
Hunger	2.014	NS	-	-	-	-	-	-
Memory of sensory satisfaction	4.918	.003	-	-	14.010	.000	-	-
Pleasant Stomach feeling	.275	NS	-	-	-	-	-	-
Energy Level	1.450	NS	-	-	-	-	-	-
Satisfaction	3.094	.029	.017	NS	9.151	.003	.119	NS

* When adjusting for pre intake physical wellbeing, the effect becomes not significant

Table 5. Mean and standard deviation for during intake variables for each product measured on 9-point hedonic scale

Product	Liking of appearance		Liking of odour		Liking of taste		Liking of texture		Sensory satisfaction	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
MB	6.5 ^{NS}	1.7	6.0 ^{NS}	1.6	5.5 ^a	2.0	6.4 ^a	1.7	5.8 ^a	1.8
MN	6.7 ^{NS}	1.4	6.9 ^{NS}	1.4	6.0 ^{ab}	1.6	7.1 ^b	1.3	6.3 ^{ab}	1.4
TB	6.3 ^{NS}	1.7	5.9 ^{NS}	1.5	5.7 ^{ab}	1.8	6.7 ^{ab}	1.4	5.8 ^{ab}	1.7
TN	6.8 ^{NS}	1.7	6.0 ^{NS}	1.6	6.2 ^b	2.0	7.1 ^b	1.6	6.3 ^b	1.7

^{a, b} Common superscripts within a column do not differ significantly

^{ns} Indicates not significant

Table 6. Mean and standard deviation for post- and one hour post intake variables for each product measured on 9-point hedonic scale. Only variables with significant product effects are included in the table.

Product	Satisfaction post intake		Memory of sensory satisfaction		Fulfilment of expectations		Fullness		Desire to eat again		Satisfaction one hour post intake	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
MB	5.5 ^{ad}	1.8			5.5 ^a	2.2	5.1 ^a	1.7	5.4 ^b	2.4	5.5 ^{ad}	2.1
MN	6.1 ^{abc}	1.5			6.3 ^b	1.7	5.2 ^a	1.7	6.4 ^a	1.9	6.0 ^{abc}	1.7
TB	5.6 ^{abd}	1.8			5.4 ^a	2.0	5.3 ^{ab}	1.9	5.5 ^{ab}	2.2	5.4 ^{abd}	1.9
TN	6.1 ^{bd}	1.7			6.3 ^b	1.7	5.9 ^b	1.9	6.2 ^{ab}	2.1	6.1 ^{bd}	1.8

^{a, b, c, d} Common superscripts within a column do not differ significantly

3.1.2 Influential variables in food satisfaction

Table 7 provide an overview of how influential variables' were in food satisfaction immediately- and one hour post intake. Figure 1 and 2 show PCA plots including only variables found moderately or highly influential for food satisfaction immediately after intake and one hour post intake respectively.

Sensory satisfaction and memory of sensory satisfaction were found highly influential variables in food satisfaction immediately- and one hour after intake respectively. The role of sensory properties in our appreciation of food is supported by the broad range of studies and models focusing on: sensory properties and acceptance (e.g. Harper, 1981; Land, D.G., 1983; Tuorila, 2007), sensory properties and preference (e.g. Khan, 1981), sensory properties and food behaviour (e.g. Cardello, 1996; Fürst et al, 1996; Connors et al, 2001; Mojet, 2007) and liking as a determinant for intake (e.g. Drewnowski & Hann, 1999)..

Sensory boredom as the primary reason for ending intake influenced food satisfaction negatively. Consumer probably rate sensory boredom negatively as an increasing proportion of human food consumption are driven by pleasure, not just by the need for calories (Lowe & Butryn, 2007). When boredom is rated as the primary reason for ending intake, it indicates that the consumer is not physiologically full but are satiated to the sensory properties of the food, a phenomenon we know as sensory specific satiety (SSS) (Rolls, 1986). Hunger was found to influence food satisfaction negatively (table 7). This result harmonise with the general main purpose of initiating a meal; namely to reduce hunger. As, if satiation is not perceived the general rewarding properties of food intake happening during the food intake cycle (Kringelbach et al., 2012) may not be fully experienced. Reduced hunger and a feeling of fullness have previously been found to be satisfying in itself (Murray & Vickers, 2009). This result further harmonise with finding that ending the meal due to satiation was highly influential on food satisfaction.

Fulfilment of expectations was found moderately influential in food satisfaction immediately after intake (table 7). The fact that the expectations towards the products (pre intake) did not vary

between products, indicate that it is not the expectations in themselves that drive the hedonic experience, but how these expectations are confirmed/disconfirmed by the product when perceived. However, it is questionable why fulfilment of expectations could be regarded a main determinant to food satisfaction, when the category in the rating of product performance, “as expected”, could not. The two variables were meant to reflect about the same response. However, when reflecting on the phrasing the question about fulfilment of expectations, “do you feel your expectations are fulfilled?”, the question itself did not guide the consumer in how to interpret or answer the term. This means, what consumers focused on when answering the question could have varied between subjects. As fulfilment of expectations in general are positively associated with food satisfaction (figure 1), the results indicate that consumers could have passed their subjective hedonic ratings of the products onto the evaluation of fulfilment of expectations. For future studies, a more specific phrasing of the question would be advisable or simply leaving out the question and keep the question about product performance. In the question about product performance consumers are guided to evaluate product performance relative to expectations prior to intake. Guiding consumers in what to rate increase the interpretability of results. Previous research have focused on fulfilment of expectations about hedonic experience of sensory characteristics (A. V. Cardello & Sawyer, 1992). Results of product performance show disconfirmed expectations highly influential on food satisfaction, as delight (product performance better than expected) was positively influencing food satisfaction and disappointment (product performance worse than expected) was negatively influencing food satisfaction. These results reflect well the general theory about disconfirmed expectations in satisfaction (Deliza & Macfie, 1996).

Other variables that were found influential of food satisfaction one hour post intake were: pleasantness of stomach feelings and energy level. These results are supported by qualitative findings found by the author of this paper (currently submitted but unpublished).

Being obese was negatively associated to satisfaction immediately and one hour post intake, whereas being normal weight correlated positively to satisfaction one hour post intake. In humans there is evidence that obese individuals prefer and consume high palatability foods more than those of normal weight (Davis, Strachan, & Berkson, 2004). But if that means that obese do not experience the same degree of food satisfaction as normal weigh subjects and therefor seek highly pleasurable foods to experience satisfaction subjects are unknown. Interesting for our findings, Wang et al (2001) found that obese had lower density of D2 receptors, implying lower sensitivity to reward than subjects in the higher end of normal weight. In the paper by Davis and colleagues (2004) they speculate on a causal relationship between obesity and low sensitivity to reward, and mention that overeating could be a compensatory behaviour to increase reward to a more comfortable level.

Other influential variables in food satisfaction included: general liking of yoghurt w/muesli products, consumption frequency and attitude towards new foods. Though not sufficient to reflect subjective neophobic status, consumers’ general attitude towards new foods could serve as an indication of neophobic status, as the variable is one of several variables measured in the Food Neophobia Scale (Pliner & Hobden, 1992). Interesting for our findings, neophobic subjects have previously been found to make more negative ratings to novel products than neophilic subjects (Raudenbush & Frank, 1999). This could indicate that subject included in our study differed with regard to neophobic status, but further questions and analysis are needed to clarify this.

Table 7. Variables Important in Projection scores (VIP) found by PLSR influencing food satisfaction immediately and one hour post intake. Direction if the influence of each variable is indicated in the last column.

Determinant	Food satisfaction immediately post intake	Food satisfaction one hour post intake	Direction
Related to sensory experience			
SS	2.9	3.5*	Positive
Desire for other foods	-	-	No: positive Yes: negative
Related to psychological experience			
Psychol. Well-being	-		Positive
Fulfilled expectations	0.8		Positive
Product performance compared to expectations	Worse: 2.2 Better 1.5		Worse: negative Better: positive
Related to physical experience			
Phys. Well-being	-		Positive
Hunger	0.9	-	Negative
Fullness	-		Positive
Energy		1.6	Positive
Reason ending	Boredom: 1.4 Unpleasant: 1.0 Satiation: 1.1		Boredom, unpleasant: negative Satiation: positive
Pleasant stomach feelings		1.5	Positive
Demographic, behavioural and attitudinal variables			
Gender	-	-	No general direction
Age	-	-	No general direction
BMI	Obese: 0.9	Obese: 1.0 Normal weight: 1.0	Obese: negative Normal weight: positive
Education	-	-	No general direction
Background info			
Consumption frequency	-	1-5 times per half year: 1.0	1-5 times per half year: negative
General liking of food type	1.2	1.3	Positive
Attitude towards new foods	-	0.8	Positive

3.1.2 Comparison of influential variables for food satisfaction immediately and one hour post intake

Figure 1 and 2 shows that food satisfaction immediately- and one hour after intake are highly positively correlated to satisfaction with sensory properties. This indicates that sensory properties played an evident role in consumers' general appreciation of food not just immediately after intake but also in a longer time span from intake. VIP scores for sensory satisfaction and memory of sensory satisfaction was higher than VIP scores for the rest of the variables reflecting the more influential role of sensory properties in food satisfaction than psychological- and physical sensations (table 7). Product performance relative to consumers' expectation was further highly influential in food satisfaction immediately after intake, likewise was hunger post intake. Hunger was not found influential in food satisfaction one hour post intake but other variables related to physical well-being were; pleasant energy level and stomach feelings. This could indicate that physical well-being sensations become more important for food satisfaction one hour after intake than immediately after intake. However, as all variables were measured both immediately and one hour post intake a direct comparison is limited.

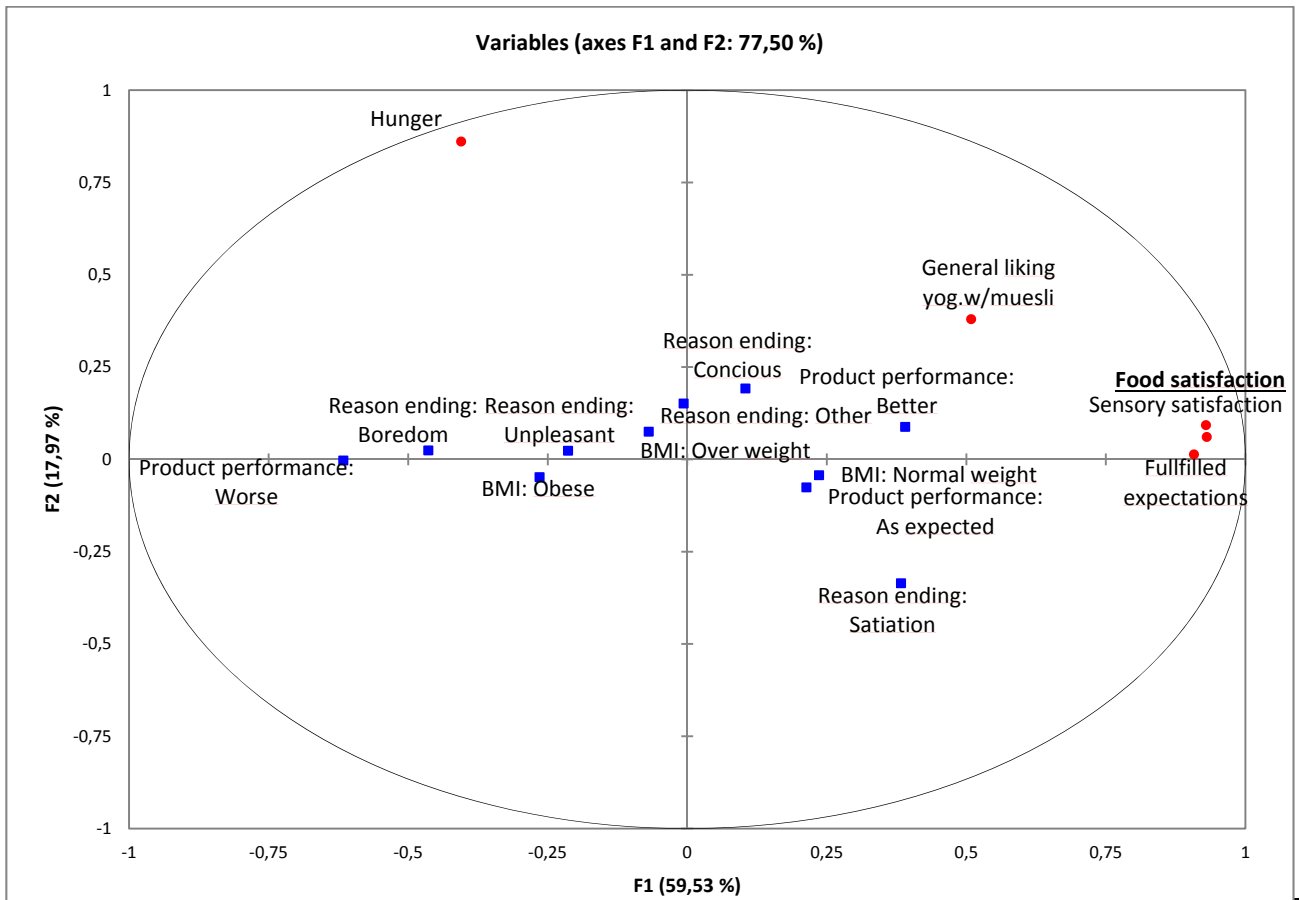


Figure .1 PCA loading plot of influential variables immediately after intake. Categorical variables are shown in blue and continuous in red, with Food satisfaction marked in bold and underlined

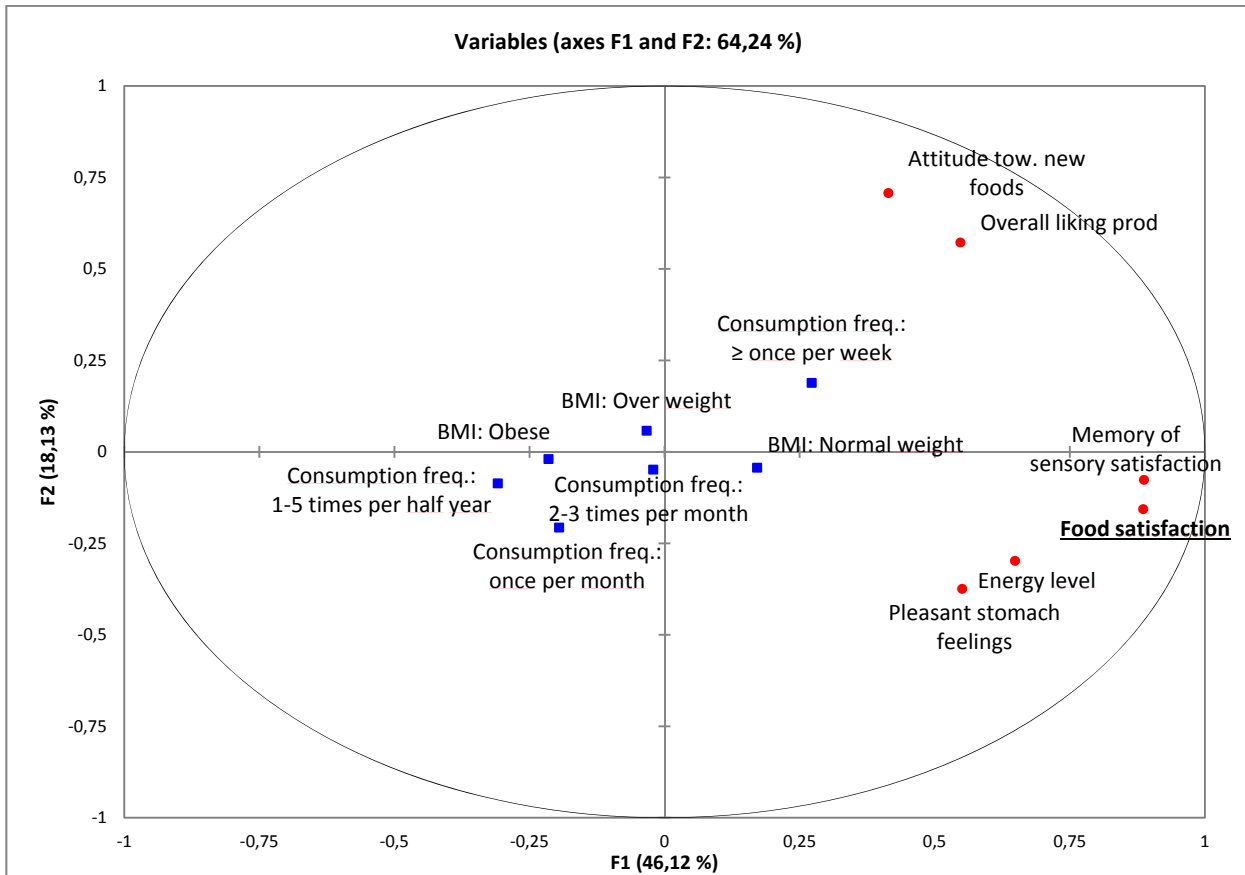


Figure 2. PCA loading plot of influential variables one hour post intake. Categorical variables are shown in blue and continuous in red, with Food satisfaction marked in bold and underlined

3.2 Sensory data

As sensory satisfaction and memory of sensory satisfaction was found highly correlated to food satisfaction immediately and one hour post intake, it was relevant to study the sensory differences between products and how they related to sensory satisfaction.

Sensory differences between products were studied using sensory profiling. Of the 20 attributes included in the profiling 11 could significantly describe the product differences. Non-significant product differences were found for the attributes: brightness (A1), solidity (A1), lactic acid (O1, F1), caramel (O1), sweetness (F1), Grains (F1), astringency (T1) and crispiness (T3).

Principal Component analysis was applied for mean intensity scores, a bi-plot can be seen in figure 3. PCA results showed that the two first components explained 98.5% of data variation. The first component explained 90.9% and was mainly related to odour and flavour attributes. In the positive part of PC1 were the two nut-containing yoghurt w/muesli products. These products were rated higher for the odour attributes: dusty, nuts and grains, and the flavour attributes: caramel and nuts compared to the berry-containing yoghurt w/muesli products. The latter two (TB and MB) were at the negative end of PC1 and characterised by being more crispy (T1), having a more intense sweet and berry odour, berry flavour and the yoghurt were more coloured by the muesli (attribute: Set off). PC2 explained 7.6% of data variability and differentiated TB and MN from MB and TN with MN and TB characterised by having more intact muesli. However, the attribute was only significantly different between product MN and MB.

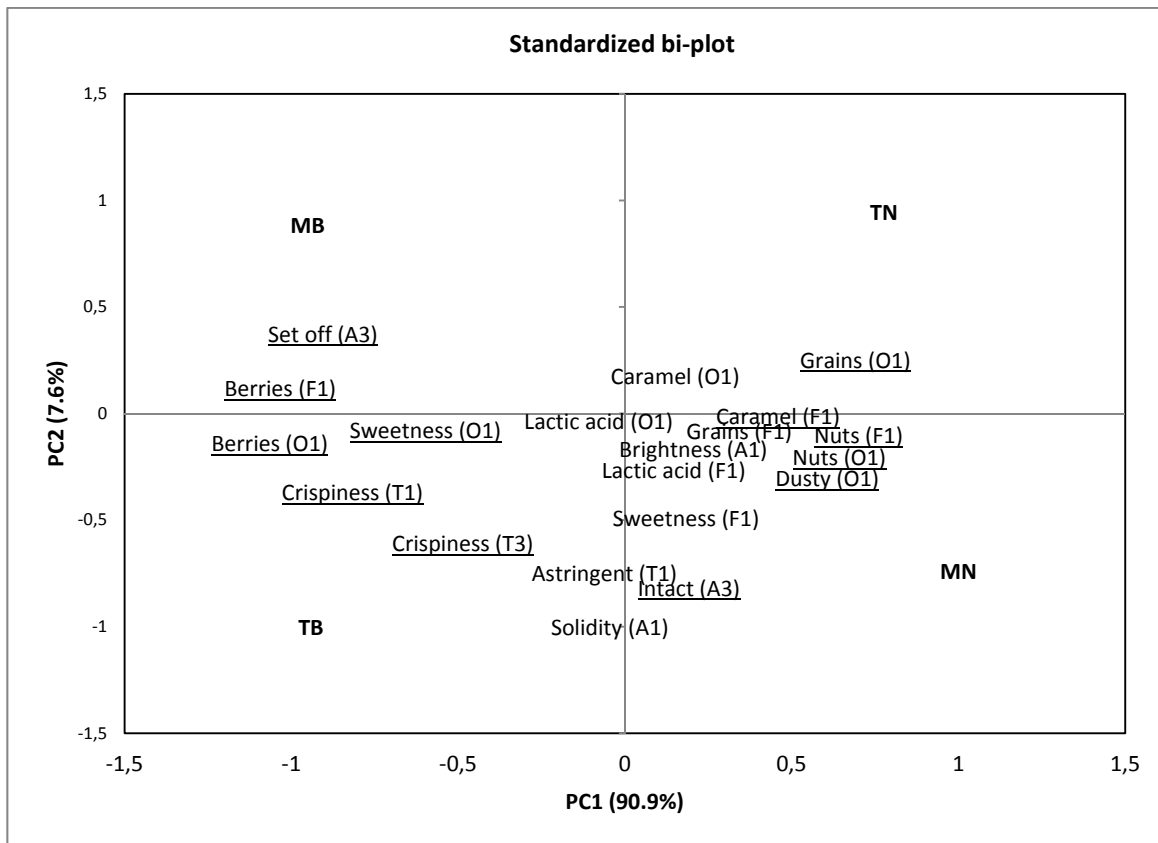


Figure 3. Principal Component Analysis biplot of yoghurt w/muesli products as scores and mean sensory attributes as loadings. Attributes that significantly discriminate products are underlined. Letters in brackets indicate: A = appearance, O = odour, F = flavour, T = texture. Numbers in brackets indicate: 1 = evaluated immediately, 3 = evaluated after 3 minutes.

ANOVA-lmer, applied to attributes that significantly discriminated products, showed that significant differences between products could be regarded a muesli effect for all attributes (all p-values < .0001 except $p_{\text{SweetnessO1}} = .015$ and $p_{\text{GrainsF1}} = .011$) except: Intact muesli (A3), for which, the effect could be regarded an yoghurt*muesli interaction effect (all p-values < .05). That the mueslis dominated the perception of the products were therefor not only seen in the consumer study but also supported by the objective sensory analysis. This indicates that the sensory properties of the mueslis probably masked potential sensory differences between the yoghurts.

When comparing consumer's ratings of sensory satisfaction with the quantitative descriptive analysis of sensory attributes, sensory satisfaction was driven by the grainy, nutty and dusty odour, and the caramelised and nutty flavour that characterised the TN product (figure 3). Consumers found the MB yoghurt w /muesli product the least sensory satisfying. This product was characterised by colour set off from muesli to yoghurt, high intensity of crispiness and sweetness, and an odour and flavour of berries.

4. Conclusion

The present study showed that variables influencing food satisfaction immediately and one hour post intake was related to the sensory experience and memory hereof, physical sensations as well as socio demographics.

Variables highly influential for food satisfaction immediately after intake included: sensory satisfaction, product performance relative to expectations, reason for ending intake and general liking of yoghurt w/muesli products. Variables highly influential for food satisfaction one hour post intake included: memory of sensory satisfaction, experiencing pleasant energy level and stomach feelings, BMI status, consumption frequency and general liking of yoghurt w/muesli products.

Together these result show sensory properties to have a prominent role in food satisfaction.

Analysis of consumer data showed that differences in consumers' perceptions of products to a large extent could be regarded a muesli effect. Similar findings were found for objective sensory data where profiling of products to a large extent was dominated by attributes characterising the mueslis.

Consumers found the products containing muesli characterised by nuts and grains more satisfying than the mueslis characterised by berries. Only ratings of fullness post intake were found driven by a yoghurt effect. Together these results indicate that the industry can replace low protein yoghurts with protein rich variants with the result that consumers will feel an increased fullness post intake.

Possible sensory differences between the yoghurts seem to be masked by the mueslis.

Further studies are needed to compare the role physical- and psychological well-being related sensations immediately versus one hour after intake. Further analyses are also needed to clarify if the findings can be generalised to a broader range of yoghurt w/muesli products as well as other food types.

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PV

Factors important for sensory satisfaction and food satisfaction after intake of fruit drinks varying in sweetener and addition of aroma and fibres

Barbara Vad Andersen^{a*}, Line Holler Mielby^b, Ida Viemose^c, Wender Laurentius Petrus Bredie^c & Grethe Hyldig^a

^a*National Food Institute, Department of Industrial Food Research, DTU, Soeltofts Plads, Building 221, DK-2800 Kgs. Lyngby, Denmark*

^b*Food Metabolomics and Sensory Science, Dep. of food, Faculty of Science and Technology, Aarhus University, DK-5792 Aarslev*

^c*Department of Food Science, Section for Sensory and Consumer Science, University of Copenhagen, DK-1958 Frederiksberg*

^{*}*Corresponding author. E-mail address: bvan@food.dtu.dk Phone: 0045 45252548.*

Abstract

In the aim of limiting energy intake, stevia can replace sucrose and fibres can be added to increase satiety. However, the potential consequences related to the sensory and hedonic experience as well as physical sensations of replacing sucrose and adding fibres on consumers' degree of product satisfaction are unknown.

This study aimed: a) to study sensory and hedonic differences in perception of fruit drinks differing in use of sweetener (sucrose versus stevia) and addition of lime zest aroma and fibres (oat beta-glucans) b) to study whether the product differences led to differences in the physical sensations immediately up until 40 minutes after intake, and c) to study the main drivers of satisfaction.

Sensory profiling was used to study sensory attributes that discriminated between the fruit drinks. Additionally a randomized cross-over consumer study was conducted using 66 subjects. Hedonic ratings of sensory perceptions and subjective ratings of physical sensations were collected up to 40 minutes post intake.

Significant sensory and hedonic differences were found between all fruit drinks, except the ones varying in type of sweetener only. Differences in physical sensations were found immediately- and 10 minutes post intake between fruit drinks with and without fibres. Satisfaction with sensory attributes was found to be the main driver of food satisfaction. Psychological well-being and physical sensations related to intake drove satisfaction as well. Thus, the results illustrate stevia as a likely sucrose replacer and fibre addition as a likely ingredient to increase satiety. However, adding fibres have both positive and negative effects related to physical sensations post intake. In general, adding fibres without compromising satisfaction is difficult. More research is needed to establish the importance of sensory perceptions on food satisfaction relative to psychological well-being and physical sensations among a broader range of products.

Introduction

A high-calorie diet in combination with inadequate physical activity is known as the major cause of overweight and obesity. This has led to a need for substituting high-calorie food ingredients by low-calorie alternatives. Sucrose is the main sweetener used in human diets, accounting for a high percentage of the daily energy intake (Pedersen et al 2010). By replacing sucrose with a low-calorie alternative, energy intake might be reduced and ultimately help prevent the negative health consequences associated with excess eating. Stevia are among the sweeteners increasingly used, and are appreciated by consumers for its naturalness compared to synthetic sweeteners (Pawar, Krynitsky, & Rader, 2013) and for its positive health effects (for a review see (Goyal, Samsher, & Goyal, 2010)). Despite the increasing relevance of health and naturalness (Pawar et al., 2013), the sensory characteristics are regarded key determinants for a potential replacement of sucrose.

Ideally, the sweeteners should provide the same sensory characteristics as sucrose, in order to meet consumers' expectations (Cardoso & Bolini, 2008; Zorn, Alcaire, Vidal, Giménez, & Ares, 2014). Kinghorn et al (2010) suggested an evaluation of sensory characteristics such as bitterness, aftertaste (metallic, sour), texture attributes (viscosity, mouth feel) and freshness in the search for relevant sucrose alternatives. Replacing sucrose with stevia, the alternative sweetener in focus in this paper, has been associated with significant increase in bitterness, sweetness and off-flavours characterised as metallic and liquorice-like (Cardoso & Bolini, 2008; DuBois, 2012; Zorn et al., 2014). To avoid the negative sensory effects of replacing sucrose with stevia, a solution might be to use an aroma capable of masking the negative sensory characteristics of stevia.

Another alternative strategy to limit energy intake is to increase the satiating power of foods. For this purpose adding fibres to foods, have been found a relevant strategy. A review investigating the effect of fibre intake on body weight found that higher dietary fibre intake was associated with increased satiety and decreased hunger (Welch, 2011). Several mechanisms behind the effect have been proposed (for a review see (Slavin, 2007)). First, soluble fibres form a viscous gel in the gut which is believed to slow gastric emptying and lead to an increased feeling of fullness (Hoad, 2004; Howarth, 2001). Second, some viscous fibres slow absorption of glucose in the small intestine and lead to lower postprandial glycemic and insulinemic responses. Third, some researchers suggest that fibre-rich foods change gut hormones (ghrelin and glucagon-like-peptide-1) (Keenan et al., 2006; Näslund & Hellström, 2007). All of these mechanisms are suggested to increase satiety. However, it is not clear whether it is the perception of viscosity in the mouth or the viscosity within the GI tract which produces these effects. Adding fibres to foods affects the sensory profile of the food.

Significant differences in appearance-, aroma-, flavour- and texture-attributes have been reported in a study on apple-pear beverages and shrimp-dill soup with and without oat beta-glucan (Lyly, Roininen, Honkapää, Poutanen, & Lähteenmäki, 2007). Further, differences in flavour- and texture-attributes have also been found in orange-flavoured beverages with different concentrations of barley beta-glucan (Temelli, Bansema, & Stobbe, 2004). In addition to the mechanisms previously mentioned, it is suggested that the sensory characteristics themselves can affect satiety through expectations about satiety (Yeomans & Chambers, 2011), and that the presence of satiety-relevant sensory cues can lead to more effective satiety than would be seen in the absence of such cues.

Relevant for the industry is how consumers hedonically respond to their products. All sensory stimuli elicit a hedonic dimension in addition to their basic sensory qualities (Cardello, 1997), and

changing the sensory product characteristics might change the hedonic appreciation of the product, likelihood of product selection and how much we consume (Sørensen, Møller, Flint, Martens, & Raben, 2003). The sensory characteristics are not the only perceptions experienced in relation to food intake. Sensations related to the post –ingestive and post –absorptive processes, like satiety, are believed important for consumer satisfaction as well (Boelsma, Brink, Stafleu, & Hendriks, 2010), however the relative importance compared to the importance of sensory perceptions is unknown.

To our knowledge no studies have compared the effect of the use of sweeteners and addition of lime zest aroma and fibres on sensory product profile, perception of physical sensations after intake and consumer hedonic responses. The current paper present a case study on four different apple-cherry fruit drinks differing in which type of sweetener that had been used, and if fibres and/or lime zest aroma had been added. It was hypothesised that 1) replacing sucrose with stevia would change the sensory product profile which would be reflected in the consumer hedonic evaluation of foods 2) adding lime zest aroma could mask the potential sensory effects of using stevia instead of sucrose 3) adding fibres would change the sensory product profile and lead to differences in post-ingestive well-being related sensations, all important for food satisfaction.

The present case study is one of several studies focusing on factors related to food satisfaction. In the present study the focus is at: the sensory experience, the hedonic experience and post-ingestive physical sensations and their influence in food satisfaction. Note, the term “food” covers foods as well as beverages. To keep the terminology across the series of studies, the term “food satisfaction” is used, though it in this specific case “food” refers to the beverages, apple-cherry fruit drinks.

Accordingly, the aim of the current case study was: a) to study sensory and hedonic differences between fruit drinks differing in use of sweetener and addition of lime zest aroma and fibres b) to study if product differences led to differences in physical sensations at different time points post intake c) to study main drivers of food satisfaction

Method and materials

Fruit drinks

Four apple-cherry fruit drinks were used varying in: type of sweetener used and concentration of fibre and lime zest aroma added. Product characteristics can be found in Table 1. Three of the four fruit drinks contained Stevia (Granulated Pure Circle Alpha, NP Sweet A/S, Denmark) and were originally developed for a study investigating satisfaction of apple-cherry fruit drinks (unpublished data). These three were selected out of nine fruit drinks varying in three levels of added fibre and three levels of added lime zest aroma in a full factorial manner. This was done based on inspecting the Prinipal Component Analysis (PCA) scores and loadings plot of the sensory data, to select the fruit drinks with marked sensory differences. For the purpose of the study reported in the present paper, a sucrose-sweetened variant was included as well. This fruit drink was, besides the type of sweetener, the same as one of the fruit drinks sweetened with Stevia. The fruit drinks were produced in collaboration with the Danish company Rynkeby Foods A/S. The fruit drinks were portioned in bottles containing 250ml and stored in darkness at 2°C. Fruit drinks were served at 10°C.

Table 1. Characteristics of apple-cherry fruit drinks

Product	Sweetener	Level of added lime zest aroma (Döhler, Germany)	Level of added fibre (β -glucans, PromOat {1-3, 1-4} Beta Glucan, PromOat, Sweden)	Total energy content (kJ/100ml)
S	Sucrose, (26g/litre)	0g	0g	382.0
A	Stevia*, (0.09g/litre)	0g	0g	297.5
B	Stevia*, (0.09g/litre)	1ml/litre	0g	297.5
D	Stevia*, (0.09g/litre)	1 ml/litre	10g/litre	317.0

*Granulated Steviol Glycosides with a purity degree of 95% and Rebaudioside A >75%

Sensory Descriptive Analysis

Sensory profiling was conducted according to “generic sensory descriptive analysis” (Murray, Delahunty, & Baxter, 2001). The procedure included the following steps; panel selection, sample preparation, vocabulary development and training and evaluation and was similar to the one described in (Mielby, Kildegaard, Gabrielsen, Edelenbos, & Thybo, 2012). The panel consisted of 9 assessors (six females and three males, aged between 35 and 59 years), having one to five years of experience with sensory evaluation of various foods incl. fruit drinks.

Prior to the evaluation of fruit drinks, the panel went through a vocabulary development session and a training session of two hours duration each. During the vocabulary development the panel and panel leader developed the initial vocabulary based on a subset of the fruit drinks which spanned the sensory variation of the total product set. During the training sessions the panellists were given reference materials to further clarify and develop the meaning of the vocabulary. The final vocabulary can be seen in Table 2.

The sensory profiling was performed in a sensory evaluation laboratory that complies with international standards (ASTM 1986). Samples were served at 15°C in colourless plastic cups (Abena A/S, Aabenraa, Denmark) containing 30 ml. The intensity of the sensory attributes was registered on a 15 cm unstructured continuous scale with anchor point “low-” and “high intensity” using the Fizz Software (2.30 C, Biosystemes, Couternon, France). Profiling was carried out in one session scheduled for two hours. The samples were evaluated in five replicates according to a block design and presented in a balanced order to account for sample order and carry-over (MacFie, Bratchell, Greenhoff, & Vallis, 1989). To cleanse their palates the assessors had water, weak lukewarm green tea and thin crackers at their disposal.

Table 2. Vocabulary of sensory attributes. Discussed, verbally described and agreed upon during training.

Appearance	Aroma	Flavour	Taste	Mouth feel and texture
Redness	Cherry	Cherry	Sweet	Creamy
Clarity	Apple	Apple	Sour	Thickness
	Lime zest	Lime zest	Aftertaste (liquorice)	
	Boiled fruit	Boiled fruit		

Consumer study

A total of 66 consumers participated in a cross-over consumer study and evaluated the four fruit drinks. Inclusion criteria were: consumers, who liked fruit drinks, aged between 18 and 60 years of age and who were not suffering from food allergies. Participant characteristics can be seen in Table 3.

Consumers participated in four sessions, minimum one day apart. Sessions ran at time: 10 a.m., 12 noon, 2 p.m., 4 p.m. or 6 p.m., and participation around the same of day was emphasised. If participating around the time of a main meal, consumers were instructed not to consume the main meal before participating. Consumers drank and evaluated 250 ml of the four fruit drinks, one fruit drink per day, served in random order across sessions and participants. Testing took part in sensory booths to minimize inter-human effects on evaluation.

Table 3. Participant characteristics

Characteristic	Overall
N	66
Gender male, female	36, 30
Age mean, min, max	36.3, 18, 60
BMI	25.3 ± 5.0
Education ^a	7.7%, 21.5%, 4.6%, 6.2%, 40%, 20%
Frequency of fruit drink consumption ^b	38.5%, 24.6%, 23.1%, 13.8%
General food liking ^c	7.0 ± 1.6
General attitude towards new foods ^c	7.3 ± 1.0

^a lower secondary, higher secondary, higher secondary with trainee, short-length higher education (≤ two years), medium-length higher education (two to four years), long higher education (> four years)

^b ≥ 3 times a week, 1-2 times a week, 2-3 times a week, ≤ 1 time a month

^c mean(± std.) measured on a 9-point scale

Questionnaires were handed out before intake, and at time immediately-, 10-, 20- 30- and 40 minutes post intake. An overview of the response variables in the respective questionnaires is given in Table 4, including socio-demographic and general behavioural and attitudinal questions also asked. Each questionnaire ended with an open question, where consumers could provide additional information important for their impression of the fruit drinks. To make sure that consumer filled out questionnaires with equal time intervals, a timer was set with 10 minutes intervals, indicating when to hand out the next questionnaire. The sessions lasted approximately one hour including instructions prior to each session. Of the 66 consumers 18 were monitored using the Noldus system for the purpose of studying behavioural measures of satisfaction. Questionnaire data is included in the total dataset, analysed and presented along with the rest of the data, but the results of the behavioural study are out of the scope for this paper and will be reported elsewhere.

Table 4. Response variables included in questionnaires.

Pre intake variables	Variables exclusively measured immediately post intake	Variables measured: immediately, 10, 20, 30 and 40 minutes post intake	Socio-demographic and general behavioural and attitudinal variables
Hunger	Drinkability	Feel the drink in throat	Gender
Thirst	Drinking pleasure	Feel the drink in stomach	Height
Fullness	Overall liking	Hunger	Weight
Nausea	Liking of taste	Thirst	Education
Reflux	Liking of texture	Stomach fullness	Consumption frequency
Energy level	Liking of aftertaste	Nausea	General food liking
Physical well-being	Sensory satisfaction	Reflux	General attitude towards new foods
Psychological well-being	Replacement of snack	Energy level	
Liking of appearance ^a	(also at time 40 minutes post intake)	Physical well-being	
Liking of odour ^a		Psychological well-being	
		Desire for other foods	
		Food satisfaction	

^aMean values of evaluation of four 25 ml samples

Statistical analysis of profiling data

Mixed three-way analysis of variance (ANOVA) model was applied to the sensory descriptive analysis data to study the signal-to-noise ratio (F -value) of assessors and samples with regard to the 16 sensory attributes considering assessors and replications and their interaction effects as random effects (Panel Check, version 1.4.0, Nofima Mat, Ås, Norway). Principal component analysis (PCA) on mean data was additionally applied to visualize the relationship between the significant sensory descriptive analysis attributes (Panel Check, version 1.4.0, Nofima Mat, Ås, Norway).

Analysis of consumer data with regards to within- and between product differences

Initially, data on weight and height was used to calculate BMI: weight (kg)/height (m)². Mean and standard deviation for each response variable for each product was calculated. Note, that for the response variables liking of appearance and odour data is based on evaluation of taste samples (25 ml). Each taste sample was tasted at four sessions (= four times). Effect of session was analysed by ANOVA repeated measures. As no effect of session was found, mean ratings was used in the prospective analysis.

ANOVA with repeated measures was applied to analyse within product differences from pre- to 40 min post intake (pre-, immediately-, 10-, 20-, 30- and 40 minutes post intake).

To obtain information about between products effects on pre-, immediately-, 10-, 20- 30 and 40 minutes post intake variables, ANOVA with repeated measures and following Tukey post hoc analysis were conducted using the statistical program Prisme (GraphPad Prism 4.03).

Analysis of sensory attributes that drive sensory satisfaction

To study which sensory attributes drives sensory satisfaction Partial Least Square regression (PLSR) was applied to mean sensory- (X-variables) and sensory satisfaction consumer data (Y-variable). Explanatory variables (X-variables) were centred and reduced. Variables Important in

Projection scores (VIP) were identified and analysed to find the variables that contribute most to the model. Only attributes whose VIP values were above 0.8 were regarded drivers of sensory satisfaction. For these analysis XLSTAT (version 2014.3, addinsoft SARL) were used.

Analysis of drivers of food satisfaction

To study drivers of food satisfaction post intake PLSR was applied to model the variance of food satisfaction (Y-variable) which could be explained by variance in response variables measured immediately after intake, socio demographic-, general behavioural- and attitudinal variables (X-variables). To avoid overlap, selected variables were kept out of the analysis if the meaning of the variable were covered by other variables. For example, sensory satisfaction measures consumers' hedonic response to appearance, odour, taste and texture altogether, for which reason the single liking attributes were kept out of the analysis. Physical well-being can be regarded a generalised measure of several single physical sensation variables measured e.g. nausea, hunger and energy level. In this case physical well-being is kept out of the analysis. The last response variable kept out was drinking pleasure. This variable was believed partly covered by drinkability and partly by sensory satisfaction. For demographic data, the consumers were grouped based on BMI; under-weight (<18.5), normal-weight (18.5-24.9), overweight (25-29.9) and obese (>30). For the variables: consumption frequency and education consumers were grouped according to Table 3. For the variable age, consumers were grouped in the age-groups; 18-24, 25-40, 41-55 and 56-60 years. VIP scores were analysed, and only variables with VIP score > 0.8 was regarded drivers of food satisfaction. A VIP score between 0.8 and 1 has previously been defined as moderate influential and a VIP score > 1 highly influential (Eriksson et al, 2001; Wold, 1995). PLS was run across products on raw consumer data. Explanatory variables were centred and reduced. For these analysis XLSTAT (version 2014.3, addinsoft SARL) were used.

Results

Sensory differences

All sensory attributes, except: sweet taste, sour taste and liquorice after-taste, were able to significantly distinguish between the fruit drinks (all significant p-values < .01). PCA was applied on the mean intensity scores and a bi-plot can be seen in Figure 1. The two first components had eigenvalues higher than 1, and accounted for 98.9% of data variation. The first component explained 81 % and mainly discriminated between the lime zest aroma containing fruit drinks and the fruit drinks without lime zest aroma. In the negative part of Principal Component (PC) 1 were the two samples without added lime zest aroma, S and A located. None of the sensory attributes discriminated these two products, indicating that the difference in use of sweetener in these fruit drinks could not be perceived based on the attributes included in the profiling. Fruit drink A and S were characterised as more intense in cherry and apple flavour and aroma compared to fruit drink B and D (for cherry aroma D was not significantly different from B). Additionally fruit drink A and S had the most intense boiled fruit aroma and flavour and a clear and red appearance compared to D. In the positive end of PC1 were sample B and D. These products were characterised by a more intense lime zest aroma and flavour compared to fruit drink A and S. PC2 explained 18 % of data variability and mainly differentiated sample B from D. D was characterised by a more intense

creamy mouth feel and thickness compared to A, B and S. B was characterised by having a more clear and red appearance than D, a characteristic which the fruit drink B shared with fruit drink A and S.

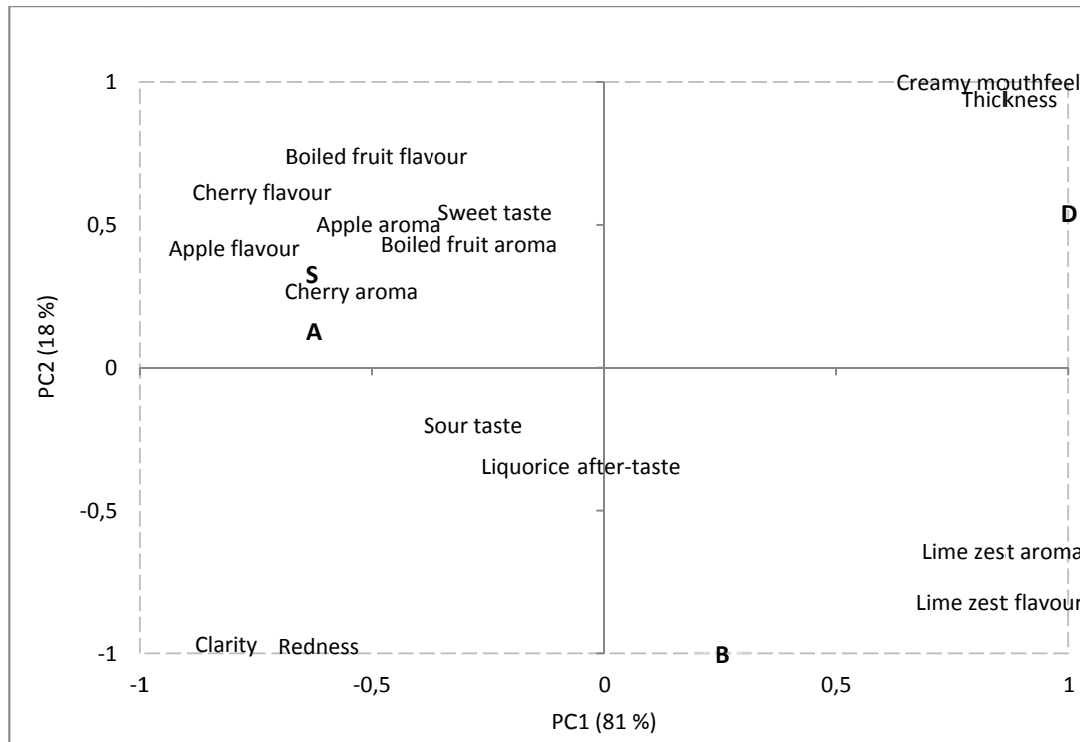


Figure 1. Principal Component Analysis bi-plot of Principal Component 1 (PC1) and Principal Component 2 (PC2), fruit drinks as scores and mean sensory attributes as loadings. Data was centred and reduced.

Hedonic evaluation of sensory properties

Table 5 shows mean hedonic ratings and standard deviations of the consumers' evaluations of the fruit drinks, as well as whether the hedonic ratings of the fruit drinks were significantly different. Consumers rated liking of the appearance and texture of fruit drink A, B and S significantly higher than fruit drink D (all p -values $< .0001$). The three fruit drinks were further rated higher in drinking pleasure compared to fruit drink D ($p < .0001$). Liking of the odour of fruit drink S was rated significantly higher than fruit drink D ($p < .0001$), whereas A and B was intermediate. Fruit drink A and S were rated significantly higher in aftertaste compared to fruit drink B ($p < .01$), while D was intermediate. No difference between fruit drinks was found for liking of taste. These hedonic differences between products seemed to be reflected well in the rating of sensory satisfaction, as the consumers rated fruit drink A and S significantly higher than D ($p < .001$), and B intermediate. When analysing overall liking ratings, no significant difference was found between the fruit drinks.

Table 5. Mean hedonic ratings (and standard deviations) including Tukey denotations for the differences between fruit drinks A, B, D and S. Information about the respective fruit drinks can be found in Table 1.

	A	B	D	S	Difference	
					F	P-value
Overall liking	6.36 (1.6)	6.01 (1.7)	5.76 (1.9)	6.42 (1.5)	1.97	NS
Liking appearance	6.72 (0.9) ^a	6.74 (1.1) ^a	5.74 (1.2) ^b	6.67 (1.0) ^a	19.0	< .0001
Liking odour	6.35 (0.9) ^{ac}	6.03 (1.3) ^{bc}	5.73 (1.5) ^b	6.41 (0.9) ^a	7.33	< .0001
Drinking pleasure	6.54 (1.4) ^a	6.25 (1.6) ^a	5.58 (2.0) ^b	6.65 (1.4) ^a	7.28	< .0001
Liking taste	6.37 (1.7)	6.03 (1.7)	5.99 (1.8)	6.5 (1.6)	0.22	NS
Liking texture	6.91 (1.2) ^a	6.71 (1.2) ^a	5.28 (2.2) ^b	6.91 (1.1) ^a	22.83	< .0001
Liking after taste	6.15 (1.5) ^a	5.60 (1.8) ^b	5.66 (1.7) ^{ab}	6.22 (1.5) ^a	4.10	< .01
Sensory satisfaction	6.42 (1.5) ^a	6.03 (1.7) ^{ab}	5.45 (2.0) ^b	6.48 (1.5) ^a	5.80	< .001

PLSR was applied to study the correlation between sensory attributes (X-variables) and sensory satisfaction (Y-variable). The two-component PLSR-model had a Q^2 cum of 0.974 indicating a very good model. Factor 1 explained 76.5% and 95.7% and Factor 2 18.7% and 3.6%, of X- and Y-variance, respectively. The model showed that sensory satisfaction correlated positively to fruit drinks (A and S) characterised by: a clear and red appearance, a sour taste, a cherry, apple and boiled fruit aroma and flavour. Sensory satisfaction correlated negatively to fruit drinks (B and D) characterised by: lime zest flavour and aroma, a creamy mouthfeel and thick texture. All variables except sweet taste and liquorice aftertaste had a VIP score above 0.8 indicating that these contributed mostly to the model.

Differences in physical sensations and food satisfaction after intake of the fruit drinks

Within product differences for the response variables; “hunger”, “thirst”, “fullness”, “nausea”, “reflux”, “energy level”, “physical well-being” and “psychological well-being” were studied from pre intake until 40 minutes post intake. For the variables; “feel the fruit drink in the throat” and “-stomach” and “food satisfaction” within product differences was studied from immediately- until 40 minutes post intake. Line charts of selected variables can be seen in Figure 2a-f. For the variable “hunger”, fruit drink B and D differed significantly over time (both $p < .001$), whereas no difference was found for fruit drink A and S. For the variables: “fullness”, “thirst”, “reflux” and “nausea” a significant difference over time was found for all fruit drinks (all $p < .01$). For “food satisfaction” a significant difference over time was found for fruit drink A, B and S (all $p < .001$), but not for fruit drink D. The development in response of the respective variables can be seen in figure 2a-f. For the remaining variables: “energy”, “physical-“ and “psychological well-being”, “feel in throat” and “-stomach” a significant difference across time was found for fruit drink A, B and S, except for “psychological well-being” for fruit drink S. For fruit drink D no significant difference over time was found except for feel the fruit drink in the throat.

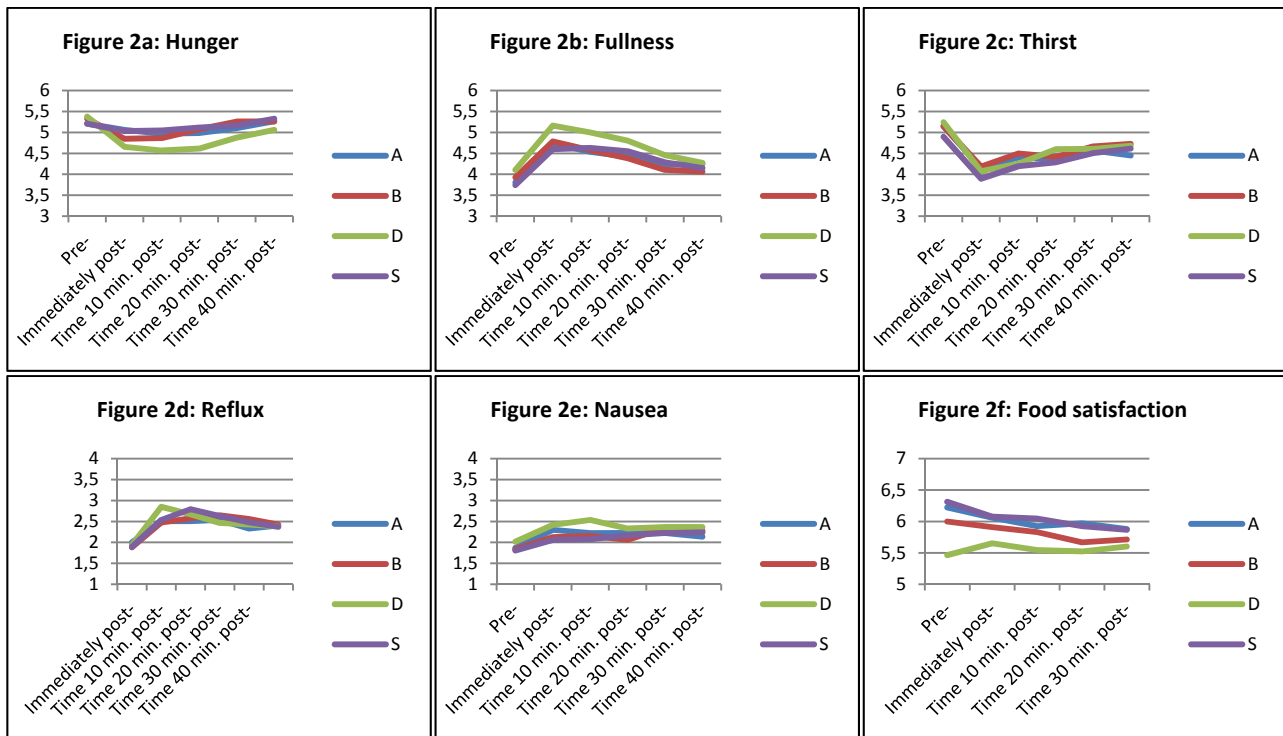


Figure 2a-f. Ratings of the sensations: hunger, fullness, thirst, reflux, nausea and food satisfaction for fruit drink A, B, D and S. Information about fruit drinks can be found in Table 1. Response variables are measured on a 9 pt. scale at times: pre- until 40 minutes post intake with a 10 minute intervals. Note that the values on the y-axis differ between figures.

No differences between products were found pre intake for any of the variables. When studying product differences for variables measured immediately post intake, a significant product difference was found for: “drinkability”, “fullness”, “food satisfaction” and if the drink could “replace a snack”. Consumers rated “drinkability” of fruit drink A, B and S significantly higher than fruit drink D ($p < .0001$). Consumer felt significantly more “full” after intake of fruit drink D compared to fruit drink S ($p = .03$), A and B were intermediate. Fruit drink D was rated significantly higher in ability to “replace a snack” ($p < .01$), but found the least “satisfying” of the four fruit drinks ($p < .01$), however not significantly different from fruit drink B. 10 minutes post intake significant differences between products were found for: “nausea” and if the fruit drink could be “felt in the stomach”. Fruit drink D was rated significantly higher than fruit drink S for both variables ($p_{\text{Feel in stomach}} = .03$, $p_{\text{nausea}} = .02$), A and B were intermediate. No significant differences were found between fruit drinks for any of the variables measured at time 20-40 minutes post intake.

Variables driving food satisfaction immediately post intake

PLSR was used to determine the variables primarily driving food satisfaction immediately post intake. Food satisfaction was included as Y-variable, and response variables measured immediately after intake, socio demographic-, general behavioural- and attitudinal variables as X-variables. Table 4 clarifies the response variables measured immediately after intake. A two factor PLSR model was carried out and the correlation plot can be seen in Figure 3. The model had a $Q^2_{\text{cum}} =$

.845 indicating a good model. Factor 1 explained 9.2% and 76.1%, and Factor 2 explained 6.6% and 8.4% of the variance in X and Y, respectively.

According to the VIP scores (not shown), the response variables which drove food satisfaction positively included: “sensory satisfaction”, “drinkability”, “snack replacer”, “psychological wellbeing”, “energy”, “fullness”, and the “age group 18-24 years”. While the response variables which drove food satisfaction in a negative manner included: “nausea” and age group “56-60 years”.

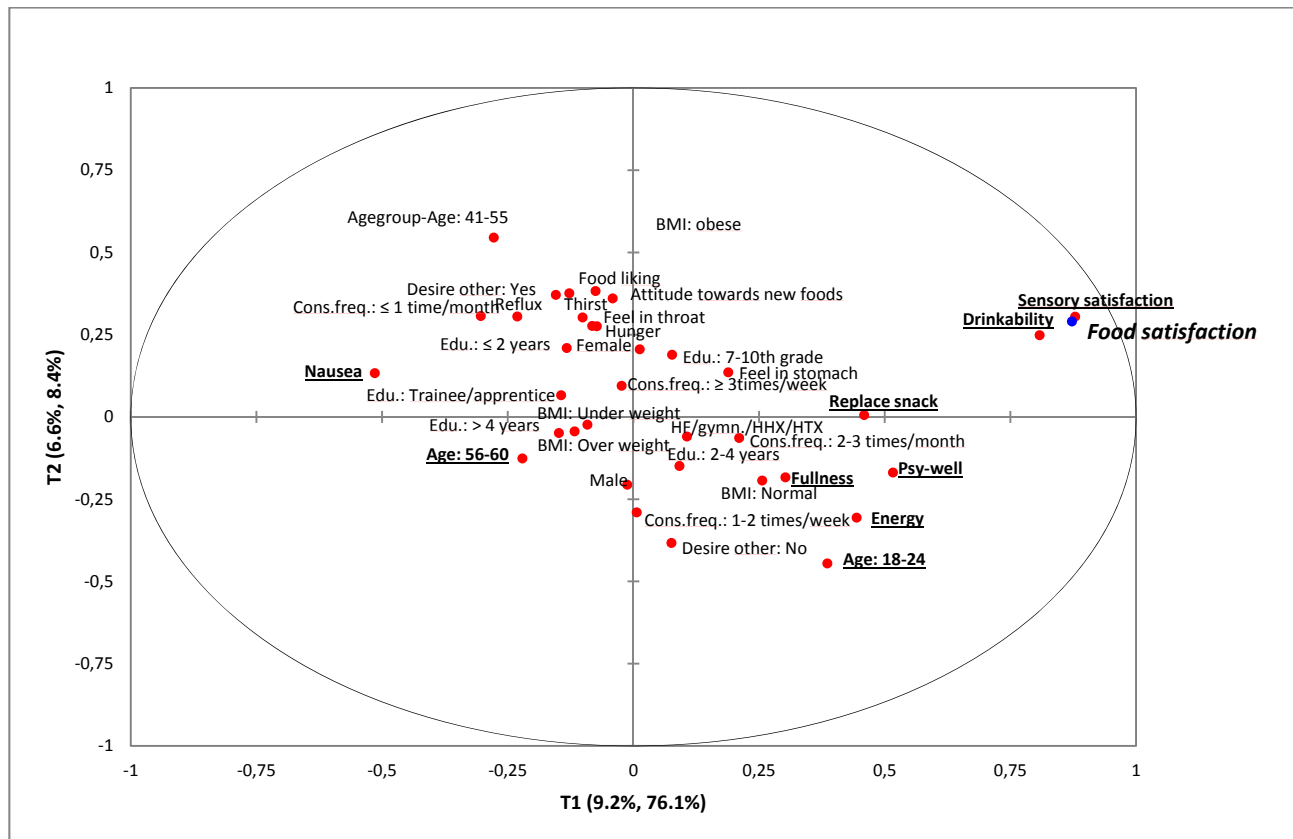


Figure 3. Partial Least Square Regression correlation plot. The dependent variable (Y), food satisfaction immediately after intake, is written in italics. Explanatory variables (X) with a VIP value > 0.8 are underlined

Discussion

The first aim was to study sensory and hedonic differences between fruit drinks differing in sweetener, and/or if fibres and lime zest aroma had been added.

No sensory or hedonic differences were found between fruit drink A and S, indicating no perceptual difference in whether sucrose or stevia was used as a sweetener. Thereby, the negative sensory characteristics: bitterness, sweetness and metallic and liquorice off-flavours which have been found in previous studies to characterize stevia containing products (Cardoso & Bolini, 2008; DuBois, 2012; Zorn et al., 2014) could not be found in this study. Bitterness, which have also been found as a negative descriptor for Stevia containing products (Cardoso & Bolini, 2008; DuBois, 2012; Zorn et al., 2014) was not evaluated by the sensory panel in the present study, and it is thus not possible

to say anything about this particular descriptor in relation to the fruit drinks. However, we know that if the level of perceived bitterness differed among the fruit drinks it would have been identified by the trained sensory panel. No difference was found between any of the fruit drinks with regards to the sweet taste. Previous studies have suggested that stevia containing products can be characterized by a lingering sweetness, indicating that a time elapse until difference in sweetness is perceived might exist. A study using Temporal Dominance of Sensations of orange juices containing sucrose and low-calorie alternative sweeteners including stevia as sweetener found that throughout the evaluation period the dominance of sweetness was significantly different between juices sweetened with stevia and with sucrose, except in the beginning of a sip (Zorn et al., 2014). This suggests that results from the present study might be affected by the time point at which the panel evaluated the products. Another explanation for the non-existing sensory differences between the fruit drink containing sugar and the one containing stevia (fruit drink A and S) could be the purity degree of the Stevia used. In the present study the stevia used had a high purity degree (97%) which is considered a very high purity degree (Bokkelen, 2012) and contained a high level of Rebauside A (>75%). Stevia extracts with a high Rebaudioside A content has been found to deliver a cleaner sweet taste with less bitterness and liquorice notes than extracts with a lower Rebaudioside A content (Bokkelen, 2012). Therefore, it can very well be that the negative characteristics of stevia found by previous studies were not present or detectable due to the high purity degree.

Acceptance of sensory properties of acerola nectar sweetened with sucrose and other sweeteners, including stevia extracts, was studied by Dutra and Bolini (2013). They found that nectar samples sweetened with stevia extracts, despite the Rebaudioside A concentration (40%, 60%, 80% and 95% respectively), were rated lower in acceptance of flavour, texture and global impression compared to sucrose sweetened samples. Hedonic ratings of appearance and aroma did not differ between samples (Dutra & Bolini, 2013). In contrast to the study by Dutra and Bolini, replacement of sucrose with stevia did not affect hedonic ratings in the present study. Hereby the results from the present sensory- and consumer study complement each other, and illustrate stevia as a promising replacer of sucrose to limit energy intake.

In our study, lime zest aroma was added in an attempt to mask potential negative sensory effect of using stevia as alternative sweetener to sucrose. However, as no differences between fruit drink A and S was evident, the relevance of a stevia-masking aroma can be questioned. Nevertheless, the lime zest aroma added in fruit drink B changed the sensory profile of the product (Figure 1). From a hedonic perspective, consumers reacted slightly negative to the addition of lime zest aroma, though a significant difference was only seen in the liking of aftertaste.

Adding fibres primarily changed the appearance- and texture-related properties (see Figure 1, B vs. D). These changes were reflected in consumer's hedonic response to liking of appearance and texture which were rated significant lower for fruit drink D.

The second aim was to study if product differences led to differences in physical sensations at different time points after intake

Consumers found fruit drink D less pleasant to drink, and rated nausea and if the fruit drink could be felt in the stomach immediately after intake higher for fruit drink D.

Focusing on the variables indicating satiety: fullness, hunger and replace a snack, it was hypothesized that addition of fibres would increase ratings of fullness and replacement of snack and decrease hunger ratings. Fruit drink D received lower ratings of hunger and higher ratings of fullness immediately post intake until 40 minutes post intake, though only significant different from fruit drink S immediately post. Consumers further found that fruit drink D to a larger extent could replace a snack immediately post intake, a characteristic probably related to the increased feeling of fullness, but at time 40 minutes post intake the effect related to replacement of snack was no longer evident. Altogether these results suggest that fibres have a potential effect on appetite. In the present study the effect was related to perceptions immediately after intake. One explanation is that the textural properties of the fruit drink caused a top-down effect reflected in the ratings of hunger, fullness and replacement of snack immediately after intake. No significant effect of fibre addition was seen in response variables 20-40 minutes post intake. A potential explanation is that the fibre content in drink D was too low to create the effects on gastric emptying and/or satiety expectations mentioned in the introduction. Another explanation lies in the selection of fibres. Research support that some fibres are more satiating than others, however it is unclear which types (and doses) that influence satiety the most (Willis, Eldridge, Beiseigel, Thomas, & Slavin, 2009). A study by Yeomans and Chambers (2011) focused on energy content and sensory differences as modifiers of satiety. They found increased perceived satiety due to an interaction effect between energy content and sensory context. More specifically they found that the sensory context in which nutrients were consumed modified subsequent satiety, with higher-energy beverages being more satiating when experienced in a thicker, creamier flavoured drink. Though energy content and texture attributes differed between fruit drinks B and D, the difference in energy content was small (19.5 kJ/100ml) suggesting that if energy differences between products had been more pronounced significant differences could have been observed. However, whether this ultimately would lead to a decreased energy intake is unknown and requires studies focusing on subsequent energy intake in following meals.

The final aim was to study which response variables that mainly drove food satisfaction. As sensory experiences, physical sensations both were believed to contribute consumers overall feeling of satisfaction, it was found interesting to compare the response variables included in the study, and study if some were more influential in food satisfaction than others.

Sensory satisfaction could be regarded the variable that mainly drove food satisfaction. This result is supported by findings in previous studies on the same topic (to be published elsewhere). Further, the findings support the general view that sensory characteristics are among the most important determinant for food acceptance (e.g. Harper, 1981; Land, D.G., 1983; Tuorila, 2007). In addition to sensory satisfaction, both psychological well-being and physical sensations drove satisfaction. This finding supports the hypothesis by Boelsma and colleagues saying that postprandial wellness, a measure defined as the subjective appreciation of food after intake, combining physiological- and psychological sensations resulting from the food intake process, may help to clarify the mechanisms of food intake, consumer satisfaction and longer term food consumption (Boelsma et al., 2010). The fact that both sensory, psychological and physical sensations seem to drive food satisfaction challenge the industry to develop a fruit drink that leave consumers with a feeling of fullness and

high energy level without compromising drinkability and sensory satisfaction. Yet, this challenge does not seem to be accomplished by adding fibres to fruit drinks. Further, the younger consumers was found more satisfied than the older consumers. If this study were used as a part of product development, it could tell the industry where to target their products. The differences in the consumers' ratings of product were too small to analyse the main drivers of satisfaction 10 to 40 minutes after intake. It can be hypothesised that sensory perceptions play a less prominent role as time from intake pass, and that physical sensations, such as satiety, play a more evident role. This should be seen in the view of the physiological processes involved in the eating processes after intake, potent to affect consumer appreciation of the food eaten (Kringelbach, Stein, & van Harteveld, 2012; Yeomans, 2010).

Limitations of the present study were the time spent finishing the fruit drinks and the non-full factorial design. Consumers being monitored spent more time finishing the fruit drink than the rest of the consumers which might have affected their perceptions and sensations after intake. Further, it would be relevant to study the effect of fibres without the addition of lime zest aroma, as it seems as if, the lime zest aroma in itself had negative consequences on liking and satisfaction.

Conclusion

The results illustrate stevia as a good candidate to replace sucrose in apple-cherry fruit drinks, as no difference was found in sensory perception and hedonic appreciation of products differing in use of sweetener only. Adding fibres to fruit drinks altered the products sensory characteristics, and caused lower drinkability and hedonic appreciation. Differences were seen in physical sensations immediately after intake and 10 minutes post intake among products with and without fibres. Immediately after intake, adding fibres increased fullness and the feeling that the fruit drink could replace a snack. 10 minutes after intake consumers reported that they to a higher degree could feel the fruit drink in the stomach, when fibres had been added to the fruit drink. These results indicate that it seems likely that fibres can be used to decrease energy intake. However, future studies are needed to clarify the long-term effects on energy intake, and if fibres can be added without jeopardising sensory satisfaction and drinkability.

In the study of factors influential in food satisfaction; sensory satisfaction was found the most important response variable, but sensations related to the physical experience and psychological well-being influenced satisfaction as well. More research is needed to support these findings and investigate if the results can be generalised to a broader range of beverage- and food products. From a methodological point of view, information about “drinkability”, “fullness”, “food satisfaction”, “if the fruit drink can replace a snack” and “nauseansness” holds potential for describing differences among products, as these response variables were found to discriminate products in the present case study.

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PVI

The relation between “liking of sensory properties” and “sensory satisfaction”. A comparison to “overall liking”.

Barbara Vad Andersen^{a*}, Per Bruun Brockhoff^b, Grethe Hyldig^a

^a*National Food Institute, Department of Industrial Food Research, DTU, Soeltofts Plads, Building 221, DK-2800 Kgs. Lyngby, Denmark*

^b*DTU Compute, Danish Technical University, Matematiktorvet, Building 324, DK-2800 Kgs. Lyngby, Denmark*

**Corresponding author. E-mail address: bvan@food.dtu.dk*

Abstract

An analysis of the primary hedonic drivers of liking and sensory satisfaction will provide valuable information to product developers on which sensory properties to emphasise the most. The present paper analyses the relative importance of liking of sensory properties; appearance, odour, taste and texture, when consumers rated overall liking and sensory satisfaction respectively. Four apple-cherry fruit drinks were used in a cross-over consumer study on 67 subjects. The fruit drinks varied in: type of sweetener used, and addition of aroma and fibre.

The main aims of the present study were a) to study if liking of the sensory properties: appearance, odour, taste and texture were considered equally, when consumers rated overall liking and sensory satisfaction b) to study if the relation depended on, whether liking of sensory properties were related to overall liking or sensory satisfaction, and c) to study individual differences in, which sensory properties the consumer primarily paid attention to when rating overall liking and sensory satisfaction, respectively.

Results showed that liking of sensory properties differed in relation to overall liking and sensory satisfaction respectively. Consumers primarily paid attention to liking of taste, when evaluating overall liking and sensory satisfaction, respectively. However, individual differences were found.

Highlights

- Consumers do not pay equal attention to liking of appearance, odour, taste and texture in their hedonic ratings of apple-cherry fruit drinks
- Most consumers primarily pay attention to liking of taste when rating overall liking and sensory satisfaction, respectively
- The importance of taste varied between individuals

Introduction

Hedonic measures are used by the industry when developing, maintaining and optimizing their products (Stone & Sidel, 1993). This is with good cause, as the hedonic aspect of foods is one of the most important parameters behind consumers' food choice (Sørensen, Møller, Flint, Martens, & Raben, 2003), and to ensure product success, companies need consumers to repeatedly choose their products. One common way to determine hedonic food appreciation is through the measure of liking/disliking (Cardello, Schutz, Snow, & Leshner, 2000), most often done through the 9-point hedonic scale (Lim, 2011; Peryam & Pilgrim, 1957). Yet, what drives liking? When a consumer says he/she likes the food, which sensory properties are then considered? Are all sensory properties considered equal, or do some properties drive liking more than others? Previous research points in the direction of "taste" as the most important sensory input (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz & Krieger, 1995). When rating overall liking solely, it is unknown if the consumer considers the appearance, odour and texture besides the taste. To enhance the probability that all four sensory properties are at least considered, "sensory satisfaction" are suggested as an alternative measure to overall liking. "Sensory satisfaction" has been used as an alternative to overall liking, in a number of studies in relation to the SENSWELL project (www.senswell.dk). When measuring sensory satisfaction, consumers are explicitly asked to rate satisfaction based on the appearance, odour, taste and texture altogether. Thereby, sensory satisfaction can be regarded a generalised measure of consumers' hedonic appreciation of the four sensory properties, and assumes that consumers consider appearance, odour and texture as well as taste. Nevertheless, it is relevant to study if the four properties are equally considered, when rating sensory satisfaction, and if sensory satisfaction differ from overall liking in that regard. An understanding of the sensory attributes primary driving liking/satisfaction could guide product developers in, which properties to emphasize the most.

The aims of this paper were a) to study if liking of sensory properties (appearance vs. odour vs. taste vs. texture) differ in their relation to sensory satisfaction, and overall liking -of cause recognizing that the sensory attributes may affect each other, and may not be independent of each other, and b) to study if the relation between property liking (liking of: appearance, odour, taste and texture respectively) and sensory satisfaction differ from the relation between property liking and overall liking. Finally, consumers differ greatly in their sensory preferences for a product. Some of the pioneering work by Pangborn (1970) showed that inter-individual differences existed when relating overall liking and sensory attribute intensities. But do inter-individual differences also exist for, how important liking of one sensory property is for overall liking compared to liking of other sensory properties? E.g. do all consumers agree on the fact that liking of taste is the most important sensory input for overall liking? The final aim of this study was c) to study if the relation between liking of a sensory property liking and overall liking, and sensory satisfaction respectively differed among individuals.

Using slopes, not quadratic analysis or correlations

One way to study the properties driving overall liking and sensory satisfaction is through a linear equation relating overall liking and sensory satisfaction, respectively, to liking of the sensory properties: appearance, odour, taste and texture. Analysing sensory attributes through linear analysis can be regarded contradictive to what is usually done within sensory science. In 1981 Moskowitz suggested to analyse the relation between sensory attributes and overall liking using quadratic equation instead of linear analysis (Moskowitz, 1981). This suggestion was based upon the recognition, that the relation between sensory intensity and overall liking could not be regarded linear, but a bell-shaped function with an optimum in the middle. However, the present case uses property liking (liking of appearance, odour, taste and texture, respectively) not sensory intensity. Therefore, we expect that increasing liking of one property, and keeping liking of all other properties constant, would increase overall liking / sensory satisfaction as well. It is also expected that there is no optimum for liking after which liking decreases.

In the linear equation, where liking of each property is related to overall liking and sensory satisfaction respectively, the slope of the equation measures the importance of the property; the steeper slope the higher importance.

Within sensory science, correlation coefficients are often used to study drivers of a variable. Correlations measures the degree to which the two variables are linear related. Using the correlation coefficient could result in equal relations between two linear relations, when the slopes of the relations differ, e.g. two relations are equally linear but one slope is steeper than the other. Therefore using correlation analysis could lead to different conclusions about the drivers of overall liking/sensory satisfaction than using slope analysis.

The use of slopes to illustrate relations between variables have been applied in previous studies, and found useful for identifying sensory drivers of overall liking (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz & Krieger, 1995).

Method

Fruit drinks

The fruit drinks used in this study (table 1) were originally developed for a study investigating consumers' degree of satisfaction of apple-cherry fruit drinks (unpublished data). The fruit drinks differed in which sweetener had been used and if fibres and/or lime zest aroma had been added. Nine fruit drinks varying in three levels of added fibre and three levels of added aroma were analysed by quantitative descriptive analysis. From the nine fruit drinks, three were selected for the study covered in this paper. This was done based on inspecting Principal Component Analysis (PCA) scores and loadings plot of sensory data. Fruit drinks with marked sensory differences were selected. A fourth fruit drink, sweetened with sucrose, was additionally included in the study covered in this paper. Sensory profiling was repeated to study sensory differences between fruit drinks (unpublished data). The profiling was used to study if the fruit drinks varied on sensory attributes related to appearance, odour, taste and texture, but will not be included in this paper. The profiling and following inspection of PCA scores and loadings bi-plot confirmed that fruit drinks

could be discriminated based on sensory attributes related to appearance, odour, taste as well as texture, facilitating differences in consumer hedonic appreciation of the fruit drinks. A description of fruit drinks used in this paper can be seen from table 1.

Table 1. Fruit drink characteristics

Product	Sweetener	Level of added lime aroma (Döhler, Germany)	Level of added fibre (β -glucans, PromOat {1-3, 1-4} Beta Glucan, PromOat, Sweden)
S	Sucrose, (26g/L)	0g	0g
A	Stevia, (0.09g/L)	0g	0g
B	Stevia, (0.09g/L)	1ml/L	0g
D	Stevia, (0.09g/L)	1 ml/L	10g/L

Consumer study

A total of 67 consumers completed a randomised cross-over consumer study, 37 males and 30 females between 18 and 60 years of age. Inclusion criteria were: consumers who liked fruit drinks, were between 18 and 60 years of age and were not suffering from food allergies. Participants should be able to participate in four sessions, time should be around the same for each session (10 AM, 12 noon, 2 PM, 4 PM or 6 PM) and sessions should as a minimum be one day apart. When participating around the time of a main meal, participants were instructed not to consume the main meal before participating. Fruit drinks were served as taste samples of 25 ml, in neutral plastic jars with lids. Consumers drank and evaluated stimuli four times on four separate days; one of each stimulus on each day. Order was randomized between the consumers. Consumers rated the products according to "overall liking", "liking of appearance", "liking of odour", "liking of taste", "liking of texture" and "sensory satisfaction", in the order presented here. Overall liking and liking of sensory attributes followed the form "how much do you like the ...". The variables were rated on a 9-point labelled scale with categories ranging from "dislike extremely" to "like extremely". Sensory satisfaction was evaluated by asking "considering the fruit drinks appearance, odour, taste and texture altogether, how satisfied are you then?". Ratings were collected on a 9-point labelled scale ranging from "extremely unsatisfied" to "extremely satisfied". As the study reflected in this paper was a part of a larger study, questionnaires pre- and post intake were included in the study as well, but will not be presented here.

Statistical analysis

Mixed models were applied to the data to study subject, session, time and sample effects for each of the six variables; overall liking, liking of appearance, odour, taste and texture respectively, and sensory satisfaction. Initially the full mixed model with interactions was applied. Following, factors were eliminated if significant effects were not found. For this part the PCA on standardized data was applied to data to visually inspect main subject, session, time and sample effects.

For each consumer, slopes of a regression line were calculated based on four corresponding (x,y) observations, one for each product. Y was either overall liking or sensory satisfaction, and X was liking of one of the four properties: appearance, odour, taste and texture. In all cases the observations were mean across subjects, sessions and time. The slopes were used for relative slope analysis.

For this part, any negative or non-estimable slope (due to zero variability) would be set at 0.

In the analysis of relations between liking of a property and overall liking and sensory satisfaction respectively, it was first investigated: How do liking of the single properties relate to overall liking and sensory satisfaction respectively? To answer this question, the slopes were calculated, and paired t-test applied to analyse if the respective slopes differed from 0. To interpret which sensory property consumers' primarily paid attention to, relative slopes were calculated (table?); $\text{Relative slope} = (\text{absolute value of raw property slope}) / (\text{sum of all raw property slopes})$. The relative slopes add up to 1.0. If consumers pay equal attention to liking of all four attribute likings each variable would have a relative slope mean of 0.25. The closer the variable lie to 1 the more attention the consumers pay to that attribute liking.

Next it was investigated: does the relation between liking of one sensory property and overall liking differ from liking of another property and overall liking? In this case, the slopes were compared through paired t-test to analyse if the relations differed. Comparisons were done for all possible combinations and repeated for sensory satisfaction. Finally, it was investigated if the relation between liking of a sensory property and overall liking different from liking of the same sensory property and sensory satisfaction. This analysis should clarify, if a sensory property is equally considered when asking consumers to rate overall liking and sensory satisfaction. Paired t-test was applied to compare the slopes.

To visualise individual differences, the normalised slopes were plotted in a triangular plot. Each vertex in the triangular plot corresponded to liking of a sensory property. The three properties; appearance, taste and texture were chosen, as consumers primarily paid attention liking of these when evaluating overall liking and sensory satisfaction respectively. Further, by including liking of these variables, the results could be compared to previous findings on the same topic (H. R. Moskowitz & Krieger, 1992; Howard R. Moskowitz, 1995). The four relative slopes were ranked, to investigate individual differences in which property thr consumer primarily paid attention to.

All statistical analysis was conducted using R (R Core Team, 2014). For the mixed model analysis the R-packages *lme4* (Bates et al, 2014) and *lmerTest* (Kuznetsova et al., 2014) were used. All statistical tests were carried out with $\alpha = .05$.

Results and discussion

Consumer study

A significant main sample effect was seen for all six variables: overall liking, liking of appearance, odour, taste and texture respectively, and sensory satisfaction (all p-values < .00). Mean hedonic scores and standard deviations can be seen from table 2. For interaction effects involving "sample",

a significant sample*time interaction effect was observed for liking of appearance and liking of odour (both p-values < .05). A significant sample*session interaction effect was seen for liking of texture (p-value < .00). And a significant sample*subject effect was found for overall liking and liking of odour, taste and texture (all p-values < .00). No main effect of session and time was found for any of the variables, whereas a subject effect was found for all variables (all p-values < .0001).

Table 2. Mean hedonic scores and standard deviations for product A, B, D and S

	A	B	D	S
Overall liking	6.49 (± 1.2)	6.10 (± 1.6)	5.59 (± 1.8)	6.60 (± 1.4)
Liking appearance	6.72 (± 1.2)	6.74 (± 1.2)	5.74 (± 1.5)	6.67 (± 1.2)
Liking odour	6.35 (± 1.2)	6.03 (± 1.5)	5.73 (± 1.8)	6.41 (± 1.1)
Liking taste	6.48 (± 1.5)	6.12 (± 1.7)	5.57 (± 1.8)	6.58 (± 1.4)
Liking texture	6.84 (± 1.1)	6.69 (± 1.2)	5.71 (± 1.8)	6.89 (± 1.1)
Sensory satisfaction	6.32 (± 1.5)	6.04 (± 1.7)	5.38 (± 1.8)	6.41 (± 1.5)

Slopes

How liking of the single properties related to overall liking and sensory satisfaction respectively was investigated. All slopes significantly differed from 0. P-values and raw mean slopes can be seen from table 3.

When comparing slopes relating liking of sensory properties and sensory satisfaction, the steepest slope was found between liking of taste and sensory satisfaction. The same pattern between slopes was found for sensory satisfaction and overall liking.

Table 3. Mean slope between liking of: appearance, odour, taste and texture respectively, and sensory satisfaction and overall liking respectively. Slopes differed from 0, when $p < .05$

	Sensory satisfaction			Overall liking		
	t	p-value	Mean slope	t	p-value	Mean slope
Appearance	5.01	< .000	.54	4.58	< .000	.51
Odour	2.33	= .023	.39	2.85	= .006	.40
Taste	11.11	< .000	.88	16.54	< .000	.87
texture	4.02	< .000	.55	4.83	< .000	.61

From the raw slopes, relative slopes were calculated. The relative slopes, shown in table 4, were used to interpret the properties consumers primarily pay attention to when evaluating sensory satisfaction and overall liking respectively. From table 4 it can be seen that consumers as a whole did not pay equal attention to all properties. Consumers primarily paid attention to liking of taste, and least attention to liking of odour. Moskowitz and Krieger (1992; 1995) likewise found that liking of taste was the main driver of overall liking. However, in their study liking of odour was not included, so a direct comparison is not possible for this property.

Pairwise comparisons of liking of each property in their relation to sensory satisfaction and overall liking, respectively, showed that the slope between liking of taste and sensory satisfaction and overall liking, respectively, differed significantly from relations between the rest of the attribute liking and sensory satisfaction and overall liking respectively (all p-values < .05). Liking of appearance, odour and texture did not differ in their relation to sensory satisfaction and overall liking, respectively (all p-values > .05). From these analyses it can be concluded that consumers paid significantly more attention to liking of taste when rating sensory satisfaction and overall

liking respectively. But though consumers tended to pay at least attention to liking of odour, no significant difference was found between liking of odour and appearance, and texture respectively.

Table 4. Raw and relative mean slopes between liking of: appearance, odour, taste and texture respectively, and sensory satisfaction and overall liking respectively

	Sensory satisfaction				Overall liking			
	t	95% CI	Raw mean slope	Relative mean slope	t	95% CI	Raw mean slope	Relative mean slope
Appearance	5.01	0.33 – 0.76	0.54	0.23	4.58	0.29 – 0.73	0.51	0.21
Odour	2.33	0.06 – 0.72	0.39	0.16	2.85	0.12 – 0.67	0.40	0.17
Taste	11.11	0.72 – 1.03	0.88	0.37	16.54	0.77 – 0.98	0.87	0.36
Texture	4.02	0.28 – 0.83	0.55	0.23	4.83	0.36 – 0.86	0.61	0.25

Paired t-test showed that the slope between liking of appearance and sensory satisfaction did not differ from the slope between liking of appearance and overall liking ($p > .05$). The same tendency was found for the remaining three sensory properties; odour, taste and texture (all p -values $> .05$). These findings showed, regardless of whether consumers are asked to consider appearance, odour, taste and texture altogether (sensory satisfaction) or not (overall likings), it did not cause a shift in how much attention the single properties were allocated. Liking of taste was the primary driver, regardless of whether consumers rated sensory satisfaction or overall liking.

Individual differences

The normalised slopes between liking of: appearance, taste and texture and sensory satisfaction (figure 1), and overall liking (figure 1) are plotted in the triangular plots shown in figure 1 and 2 respectively. The triangular plots visualise the relative importance of the sensory properties for each consumer. Each point in the figure corresponds to a consumer. Points lying very close to or on a vertex suggest that the consumer primarily paid attention to that sensory property. Points lying midway between two vertices mean that the consumer paid equally attention to both sensory properties. Points in the middle of the triangular suggest that the consumer paid approximately the same attention to all three properties. From figure 1 and 2 it can be found that most consumers paid more attention to taste than they did to appearance and texture. No clear tendency was found regarding, which property consumers on average paid second most attention to. From figure ? and ? it was further found that individuals differ in what property they primarily paid attention to. Further, very few consumers rated overall liking and/or sensory satisfaction based on one property only, a few paid attention to two properties, but most consumers paid attention to all three properties. When comparing the two triangular plots (figure 1 and 2) no clear difference can be found between sensory satisfaction and overall liking.

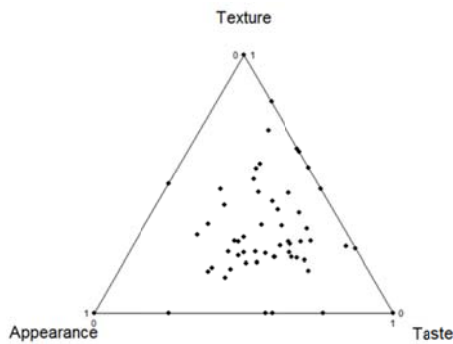


Figure 1. Triangular plot of relative slopes between the sensory properties and sensory satisfaction. Information on how to read the figure can be found in the section “individual differences”

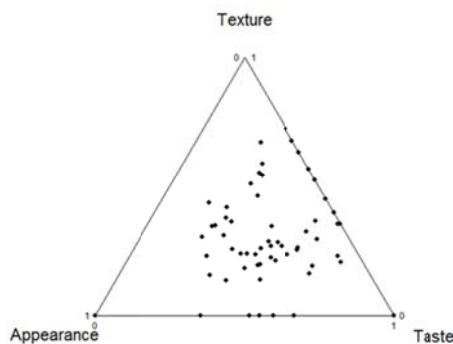


Figure 2. Triangular plot of relative slopes between the sensory properties and overall liking. Information on how to read the figure can be found in the section “individual differences”

Based upon the slopes, the sensory properties were ranked, so that ranking 1 represents the highest relative slope. The results for sensory satisfaction are shown in table 5 and for overall liking in table 6.

The results showed that for 37% of consumers, taste was the most important sensory property when evaluation sensory satisfaction. For 19% of the consumers were appearance, odour and texture respectively the most important sensory property. Only for 5% of consumers were taste the least important property, whereas for 30%, 22% and 19% of consumers respectively, were appearance, odour and texture the least important attribute.

The same tendency was found for the importance sensory properties when evaluation overall liking. The results showed that for 42% of consumers, taste was the most important sensory property in liking, whereas for 19%, 18% and 18%, respectively appearance, odour and texture were the most important sensory property. Further, the ranking showed that for only 9% of consumers taste was the least important sensory property, whereas 27%, 30% and 19% of consumers, respectively rated appearance, odour, and texture the least important sensory property.

These findings indicated that for most consumers taste was the primary property despite evaluating sensory satisfaction or overall liking, and further, for most consumers either odour or appearance was the least important sensory property.

Table 6. Individual differences in consumers' ranking of relative slopes between liking of sensory properties; appearance, odour, taste and texture, respectively and sensory satisfaction. Rank 1 corresponds to highest relative slope and rank 4 to the lowest relative slope. Rank "in between" corresponds to all other than a unique first or last position.

	Rank 1		In between		Rank 4		Total	
	number	%	number	%	number	%	number	%
Appearance	13	19%	34	51%	20	30%	67	100%
Odour	13	19%	39	58%	15	22%	67	100%
Taste	25	37%	39	58%	3	5%	67	100%
Texture	13	19%	41	62%	13	19%	67	100%

Table 6. Individual differences in consumers' ranking of relative slopes between liking of sensory properties; appearance, odour, taste and texture, respectively and overall liking. Rank 1 corresponds to highest relative slope and rank 4 to the lowest relative slope. Rank "in between" corresponds to all other than a unique first or last position.

	Rank 1		In between		Rank 4		Total	
	number	%	number	%	number	%	number	%
Appearance	13	19%	36	54%	18	27%	67	100%
Odour	12	18%	35	52%	20	30%	67	100%
Taste	28	42%	33	49%	6	9%	67	100%
Texture	12	18%	42	63%	13	19%	67	100%

Conclusion

Previous research has taught us, that many factors influence hedonic judgements of food. These factors do not only differ between individuals, but also within an individual depending on the context. The present research adds to the complex picture of what determine consumers' hedonic rating of foods. In the present study it was found that consumers did not pay equally attention to all sensory properties in their ratings overall liking and sensory satisfaction, respectively. On average, consumers primarily paid attention to taste, no matter if consumers evaluated sensory satisfaction or overall liking. From an industrial point of view, this finding indicates that product developers within the fruit drink industry primarily should focus on taste, when developing or optimising their products. But as very few consumers only pay attention to taste, the texture, appearance and odour cannot be neglected. The importance of taste did further differ between individuals. About 40% of consumers primarily paid attention to taste, when rating their product, but around 20% found appearance, odour and texture, respectively to be the most important sensory property. Future research will have to clarify, if the order of which an individual attend the sensory properties can be generalised to a broader range of foods, both within the specific product category and across product categories.

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