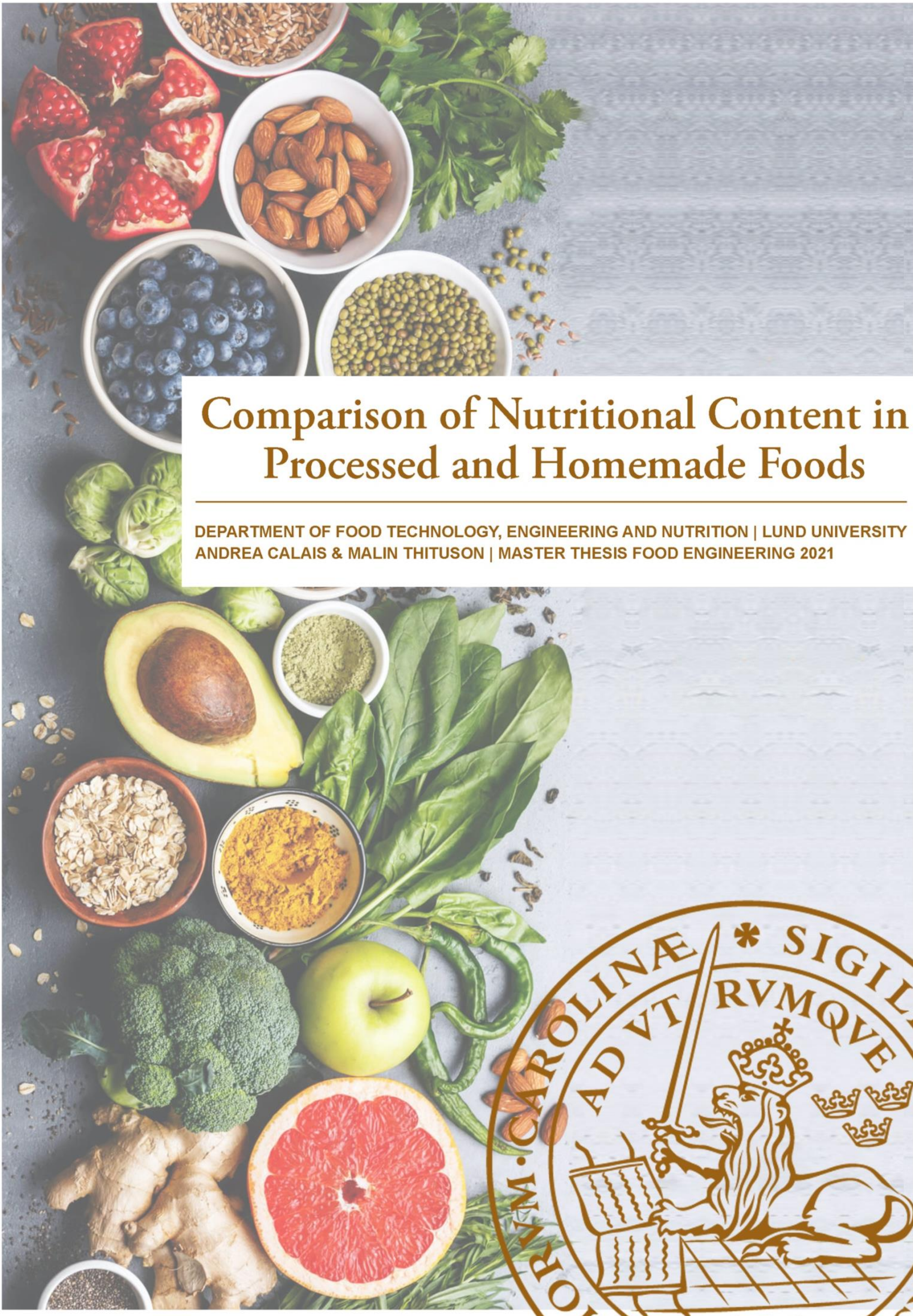

Comparison of Nutritional Content in Processed and Homemade Foods

DEPARTMENT OF FOOD TECHNOLOGY, ENGINEERING AND NUTRITION | LUND UNIVERSITY
ANDREA CALAIS & MALIN THITUSON | MASTER THESIS FOOD ENGINEERING 2021

Comparison of Nutritional Content in Processed and Homemade Foods

Orkla Foods Sweden AB

Andrea Calais & Malin Thituson

Master Thesis in Food Engineering Spring semester 2021

Department of Food Technology, Engineering and Nutrition

Supervisor LU: Andreas Håkansson, PhD, Associate Professor

Examinator LU: Karolina Östbring, Associate Senior Lecturer

Supervisor Orkla Foods Sweden AB: Rebecka Persson, Specialist Nutrition

Printed in Sweden from Media-Tryck LU.

Cover image from Shutterstock (The image is edited by us).

Lund 2021.

Abstract

This master thesis is performed in collaboration with Orkla Foods Sweden AB. The aim with this study is to investigate and compare nutritional contents in processed and homemade foods by investigating three selected ready meal products from the product range of Orkla Foods; meatballs, potato mash and pasta bolognese. This originates in a general perception that foods produced in a large-scale industry have a less adequate nutritional content compared to homemade foods.

The experimental investigation was executed by having test subjects cooking homemade dishes by using industrial recipes and raw material provided by Orkla Foods, and by using corresponding home recipes and raw material from a grocery store. These two treatments and a control product, produced in a factory, were analyzed for a selection of nutrients, based on guidelines on what nutrients to encourage and limit in the diet. By combining these, a score called Nutrient Rich Food (NRF) index was created in order to have a suitable comparative measurement of the nutrient density in each dish.

The results showed that in two out of three homemade dishes with home recipe, the meat-containing ones, the nutrient densities were significantly higher. This was mainly due to a higher meat content contributing to higher contents of protein and selected analyzed minerals. The addition of nutrient-dense vegetables, such as carrots, aided in increasing the dietary fiber and vitamin content in the pasta bolognese. In the third homemade dish, the potato mash, the nutrient density was not significantly different from the control. This was primarily because of the contents in the homemade dish which contained significantly more vitamin C which increases the nutrient density, but also significantly more saturated fat which decreases it. Furthermore, the homemade potato mash and its control seemed to be relatively similar despite the considerable difference in processing due to not that many significant differences were found.

No significant differences were found in the energy content, the salt content, nor the portion sizes. The study also saw that the saturated fat content was depending on the fat content in the raw material, as well as the addition of butter and cheese. The result showed no difference in nutritional content when the processing of the food was performed industrially or at home, when using the same industrial recipe.

The conclusion concerning the three selected ready meal products is that the largest impact of variation on the results and nutritional content in the processed and homemade variants originates from the differences in the home recipe and the industrial recipe. This is due to the addition of different raw materials in varying amounts, rather than the level of processing, i.e., the production scale and equipment used.

Sammanfattning

Detta examensarbete utförs i samarbete med Orkla Foods Sverige AB. Syftet med denna studie är att undersöka och jämföra näringsinnehållet i processade och hemlagade livsmedel genom att utreda tre utvalda färdigrätter från Orkla Foods produktsortiment; köttbullar, potatismos och pasta bolognese. Detta grundar sig i en allmän uppfattning att livsmedel som är producerade i en storskalig industri har ett sämre näringsinnehåll jämfört med hemlagad mat.

Den experimentella undersökningen utfördes genom att låta testpersoner tillaga hemlagade rätter med hjälp av industriella recept och råmaterial från Orkla Foods och genom att använda motsvarande recept från hemmet och råmaterial från mataffären. Dessa två behandlingar, plus en kontrollprodukt, producerad i fabrik, analyserades för ett urval av näringsämnen som var baserade på riktlinjer för vilka näringsämnen som uppmuntras och som bör begränsas i kosten. Genom att kombinera dessa näringsämnen skapades ett poängsystem kallat Nutrient Rich Food (NRF) index för att kunna ha ett lämpligt jämförande mått på näringstätheten i varje rätt.

Resultaten visade att två av de tre hemlagade rätterna med hemma-recept, de innehållande kött, hade signifikant högre näringstäthet. Detta berodde främst på ett högre köttinnehåll som bidrog till högre innehåll av protein och utvalda analyserade mineraler. Tillägget av näringsrika grönsaker, såsom morötter, hjälpte till att öka innehållet av kostfiber och vitamininnehållet i pasta bolognese. I den tredje hemlagade rätten, potatismoset, skiljde sig näringsdensiteten inte signifikant från kontrollen. Detta berodde främst på innehållet i det hemlagade potatismoset som innehöll signifikant mer vitamin C vilket ökade näringsdensiteten, samt signifikant mer mättat fett vilket minskade den. Dessutom verkade det hemlagade potatismoset och dess kontroll vara relativt lika trots den anmärkningsvärda skillnaden i processande på grund av att inte så många signifikanta skillnader kunde hittas.

Inga signifikanta skillnader hittades i innehållet av energi, salt eller portionsstorleken. Studien visade också att innehållet av mättat fett berodde på fettinnehållet i råvaran, liksom tillsatsen av smör och ost. Resultatet visade ingen skillnad i näringsinnehåll när processandet av maten utfördes i industrin eller hemma, när samma industriella recept användes.

Slutsatsen för de tre valda färdigrätterna är att den största påverkan av variation på resultaten och på näringsinnehållet i de processade och hemlagade varianterna härstammar från skillnaderna mellan hemmareceptet och receptet från industrin. Detta beror snarare på tillsatsen av olika råmaterial i varierande mängder, än på graden av processande, d.v.s., produktionsskalan och utrustningen.

Popular Abstract

What Actually Affects the Nutritional Content in Processed Foods?

How many times have you been at the grocery store by the ready meals section, considering if you should cook something at home, or let go of your prestige and buy a ready meal? Or how many times time have you been heating your ready meal at work, hoping that no one will notice that you did not have time to prepare a lunch box at home?

It seems like the general perception of today's consumers is that foods produced in a large-scale industry have a less adequate nutritional content than foods that are homemade. Processed food is an ambiguous and general term that often seems to be used in a negative sense, but does processing of food really affect the nutritional content? And does the nutritional composition of the food cooked at home or in the food industry differ?

Several studies from around the world indicate that consumers' perceptions of processed food are used today in a negative sense. Their opinion is that the food has a higher content of energy, saturated fat, and salt, but also that losses of nutritional properties occur during processing. However, this do not necessarily apply to processed foods. In Sweden, there is not much scientific foundation whether this view is supported by empirical evidence or not. To address this problem and contribute with more scientific results concerning processed food and its equivalent of cooking at home, this master thesis was conducted.

This was done by having test subjects cook three different dishes in a home environment with home recipes and with industrial recipes and corresponding industrially produced ready meal products. Thereafter, analyzing these dishes for a selection of nutrients creating a nutrient density for each dish. The three selected ready meal products from Orkla Foods are meatballs, potato mash and pasta bolognese.

The general perception regarding that the energy and salt content is higher in industrial foods, can be rejected for these three selected dishes as no differences were found between the home recipe and the industrially produced food. Concerning the saturated fat content, it seemed to be highly dependent on the saturated fat content in the actual raw material. This was observed in the industrial recipe for the pasta bolognese which contained significantly higher content of saturated fat compared to the home recipe, despite using the same type of meat. In general, the processing seemed to not affect the nutritional content, it was rather the composition of the recipe and the choice of raw material that were the influencing factors.

Additionally, the two meat-containing dishes with home recipes had significantly higher nutrient densities, while not being significantly higher for the homemade potato mash. One explanation for this is the amount of meat used in the different recipes. Moreover, a difference was seen in the portion size for the meatballs, where the home recipe had a significantly larger portion than the industrial meatballs. An interesting observation during the practical execution was that the test subjects seemed to plate the same number of meatballs even though the meatballs obviously weighed differently.

Lastly, this study can be of use for consumers by providing more information prior to their food choices. This study can also be applied to the food industry, where it can contribute with concrete enlightenments on how to affect the nutrient density and nutritional content of the food products.

Preface

This master thesis was performed at the Department of Food Technology, Engineering and Nutrition at the Faculty of Engineering at Lund University (LU) and in collaboration with Orkla Foods Sweden AB. This project makes up 30 credits within Food Engineering and lasted from January to June 2021 and was accomplished in Lund and in Eslöv. This master thesis was performed due to the lack of scientific evidence concerning processed foods in relation to nutritional content in Swedish food production.

A special thanks to our supervisor at LU, Andreas Håkansson, for all your valuable comments, input and discussion during this time period, and helping in improving our work. Thanks to our supervisor at Orkla Foods Sweden AB, Rebecka Persson, for all your support and knowledge, and for representing our ideas and our work for the rest of the innovation team at Orkla Foods. Thanks to our examinator at LU, Karolina Östbring, for brainstorming and interesting discussion.

Thanks to Anders Högberg at Orkla Foods for your input and for believing in us when applying for this master thesis. Thanks to Orkla Foods Sweden AB in Eslöv for letting us be in your test kitchen during these current circumstances and for providing us with raw material. Thanks to Gert Olofsson at Orkla Foods for taking your time in supporting and helping us during the practical execution in the test kitchen. Thanks to the Department of Food Technology, Engineering and Nutrition for letting us perform analyzes during these current circumstances, and thanks to Hans Bolinsson for your help. Thanks to our opponents Alva Rodhe and Bella Nielsen for your feedback and valuable comments. Finally, a big thanks to our test subjects for taking your time in creating our results. Your effort and help have been invaluable.

Thank you!

Andrea & Malin

Abbreviations

ANOVA	Analysis of variance
ANSES	Agence Nationale de Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail
	(French Agency for Food, Environmental and Occupational Health & Safety)
BMR	Basal Metabolic Rate
CFSAN	Center for Food Safety and Applied Nutrition
DASH	Dietary Approaches to Stopping Hypertension
E%	Energy percentage
EFSA	European Food Safety Authority
FAO	Food and Agriculture Organization
FHCRC	Fred Hutchinson Cancer Research Center
FSA	Food Standard Agency
IFIC	International Food Information Council
kJ	Kilojoule
LOQ	Limit of quantification
MJ	Megajoule
MRI	Maximum Recommended Intake
MUP	Markers of Ultra-Processing
NHANES	National Health and Nutrition Examination Survey
NNR	Nordic Nutrition Recommendations
NRF	Nutrient Rich Food
PAL	Physical Activity Level
RDI	Recommended Daily Intake
SFA	Swedish Food Authority
USDA	United States Department of Agriculture
WHO	World Health Organization

Table of Content

1 Introduction

1.1 Background for Master Thesis

This master thesis is based on the general perception that foods which are produced in a large-scale industry have a less adequate nutritional content than foods that are cooked at home. It is not clear where this general perception of processed food originates from. However, the existing science within this area is limited and is often based on valuations and opinions, rather than facts and evidence. Hence, it is desired to investigate whether this general perception regarding large-scale food industry in Sweden is supported by empirical data or not, as there is not much disciplinary foundation or reliable experience at present. The investigation was conducted together with Orkla Foods Sweden AB, at their factory located in Eslöv in Skåne, Sweden.

1.2 Objective

The aim of this master thesis was to investigate whether there are significant differences in nutritional values between homemade food and industrially processed food. For this purpose, three representative ready meal products from Orkla Foods Sweden AB were selected. The homemade foods were prepared with two different recipes – a home recipe and an industrial recipe, with the aim of being able to distinguish which factor that possibly could affect the nutrient values. The choice of ready meal products was based on several parameters, e.g., content, popularity, and complexity. The nutritional content involved both macro and micronutrients. The choice of which was based on a selection of the ones to encourage and of the ones to limit in a daily diet, in order to have an informative approach. The resulting values of the selected nutrients gave an indication of the nutrient density of the food. To visualize the idea behind this master thesis; imagine creating a nutrition label for the homemade food. Subsequently, comparisons of the different nutrition declarations were performed in order to get an indication of potential similarities and differences.

1.3 Research Questions

The research questions are formulated based on two areas, possibly connected to the influence on the nutritional content - the method, involving the raw material and the recipe, and the equipment. These experimental factors can be varied on two levels – home and industry. This is further explained in section 4.1. Three ready meal products from Orkla Foods' range are selected, which is further elaborated in section 3. In short, this generates three treatments: a **homemade dish with a home recipe** using raw material from a grocery store, a **homemade dish with an industrial recipe** using raw material from Orkla Foods' factory, and an industrial-made dish with the same industrial recipe and raw material, called the **control**. Based on this, the following questions are formulated:

1. Is the nutrient density significantly different (per 100 kcal and per portion) between the homemade dishes and the control for all three investigated products?
2. Is there a significant difference in portion size between the homemade dishes and the control for all three investigated products?
3. Is the energy content significantly different (per 100 g and per portion) between the homemade dishes and the control for all three investigated products?
4. What other significant differences concerning content of macro and micronutrients between the homemade dishes and the control can be distinguished for all three investigated products?

1.4 Delimitations

This master thesis is limited to the Swedish market where three industrially produced ready meal products are selected from the product portfolio produced in Orkla Foods's factory in Eslöv. Other delimitations are the number of ready meal products, the number of test subjects, and the number of nutrients to investigate due to limited time and the budget. Another delimitation is the availability in the test kitchen in Eslöv due to restrictions related to the Covid-19 pandemic. Concerning the analysis, the delimitation is to focus only on the actual existing nutritional content in processed and homemade food. Therefore, the absorption of nutrients in the body, the bioavailability of nutrients and possible interactions with other substances are not taken into consideration. This is because of individual differences among humans and is not included in the scope of this thesis. Delimitations are also made when choosing raw materials, where one specific grocery store is chosen where all the purchases take place. In addition to this, the determination of the raw materials is limited to specific brands, where the most popular ones were chosen, based on usage at online grocery stores. Furthermore, another delimitation is the sensory properties of the food, which is not taken into account. However, the three selected ready meal products are selling in large quantities and their corresponding home recipes are popular ones, which is an indication that the consumers seem to like these types of meals.

1.5 Disposition of Report

The report is divided into several major parts, where the first one is the theoretical background. This section describes different classification systems for processed food, and previous studies about homemade and processed foods and its connection to nutrition. It also describes theoretical nutritional changes during different preparation methods, as well as the Swedish dietary guidelines and recommendations and the Nutrient Rich Food (NRF) index. The second part describes the selection of ready meals products and the experimental planning, where the factors and the number of replicates is decided, as well as the home recipes. The next major part describes the practical execution, and how the analysis of the results is performed. Thereafter, comes the results, followed by the discussion and the conclusion. This report also includes an Appendix, where all the raw data and complementary information can be found.

2 Theoretical Background

2.1 What is Processed Food?

Processed food is an ambiguous and general term, where the definition varies for different authorities, below are some examples of definitions from various sources:

United States Department of Agriculture (USDA), 7 CFR § 65.220 – "Processed food item means a retail item derived from a covered commodity that has undergone specific processing resulting in a change in the character of the covered commodity, or that has been combined with at least one other covered commodity or other substantive food component (e.g., chocolate, breading, tomato sauce), except that the addition of a component (such as water, salt, or sugar) that enhances or represents a further step in the preparation of the product for consumption, would not in itself result in a processed food item. Specific processing that results in a change in the character of the covered commodity includes cooking (e.g., frying, broiling, grilling, boiling, steaming, baking, roasting), curing (e.g., salt curing, sugar curing, drying), smoking (hot or cold), and restructuring (e.g., emulsifying and extruding)." [1]

CODEX ALIMENTARIUS CAC/MISC 4 – "The term "processed food" means the product, resulting from the application of physical, chemical or biological processes or combinations of these to a "primary food commodity", intended for direct sale to the consumer, for direct use as an ingredient in the manufacture or food or for further processing." "Primary food commodities" treated with ionizing radiation, washed, sorted or submitted to similar treatment are not considered to be "processed foods." [2]

Legal Information Institute, 21 U.S. Code §321 – "The term "processed food" means any food other than a raw agricultural commodity and includes any raw agricultural commodity that has been subject to processing, such as canning, cooking, freezing, dehydration, or milling." [3]

To shortly summarize the different definitions above is that "processed food is any food that has been altered in any way in order to turn raw food into a food product". Processed food can mean different things for different people, hence classification systems for categorizing processed foods by the extent of their processing have been created. The classification of processed food differs, and it exists different systems where the criteria for the definition can vary within each system. Also, it is important to remember that these systems are often criticized for the categorization not being clear.

2.1.1 Classification Systems

It exists different classification systems that considers food processing. The following sections will go through three of them, where the most used in scientific literature is the NOVA classification [4].

2.1.1.1 NOVA

The NOVA classification system classifies all foods into four food groups according to the nature, extent and purposes of the industrial processes a food item submits. These processes could be techniques, such as physical, biological and chemical, that are used before food are consumed, turned into a meal, or after foods are separated from nature. However, as mentioned before, the NOVA classification is the most used system, but even then, the definitions may vary. One of the latest descriptions of the NOVA classification from the Food and Agriculture Organization (FAO) of the United Nations publication is used below. [4] A summary of food examples within each group can be found in Table A-1 in Appendix.

The first group is 'unprocessed and minimally processed foods'. The 'unprocessed foods', also called 'natural' foods, are edible parts of animals and plants after separation from nature. It is also foods such as fungi, algae and water. While 'minimally processed foods' are natural foods that have been modified or preserved by methods and processes in order to remove the inedible or unwanted parts. The aim with the methods or processes is either to preserve the natural food, to make it suitable for storage, to increase the safety, or just to make it more pleasant for consumers. The different processes could be grinding, drying, crushing, filtering, boiling, non-alcoholic fermentation, pasteurization, freezing or vacuum packaging. [4]

The second group is 'processed culinary ingredients', and includes substances such as salt, sugar, oils, butter and fats, that are used for preparation, cooking and seasoning. The substance can be extracted from group 1 or from nature by different processes, for instance grinding, centrifuging, milling, pressing, refining or drying. Currently, these ingredients are mostly manufactured industrially, and designed to make them more convenient for consumers. The distinctive feature is that 'processed culinary ingredients' are rarely consumed by themselves. [4]

The third group is 'processed foods', and are modified group 1 foods, where substances from group 2 such as salt, sugar, fats, or oils have been added in order to preserve and enhance sensory qualities. This could be processes and methods, such as canned or bottled vegetables or legumes preserved in brine, canning and bottling using oils, salt-pickling, and smoking. As the process will alter its nature, the intention is the infiltration of the ingredients into the food. Most of the 'processed foods' contains at least two ingredients and are generally consumed as a part of a meal. In addition to this, almost all 'processed foods' are manufactured industrially. [4]

The fourth group is 'ultra-processed foods', which are formulations of ingredients derived from foods and additives. The key point of the 'ultra-processed foods' ingredients is that there are either food substances of never or rare culinary uses in the kitchen, such as modified sugars (e.g., maltodextrin and high-fructose corn syrup), hydrogenated oils and hydrolyzed proteins, or classes of additives. There are different classes of additives such as colors, emulsifiers, artificial sweeteners, thickeners, foaming, anti-foaming, bulking, gelling, glazing agents, flavors enhancers, and flavors. All additives influence the sensory properties either by enhancing or disguising characteristics such as taste, smell, touch, looks. A signature of 'ultra-processed foods' is that it has been created by several industrial techniques and processes steps, either within one factory or in different ones, hence 'ultra-processed'. The use of ingredients and choice of processes for 'ultra-processed foods' are designed to make the final product more palatable, convenient and profitable. [4]

2.1.1.2 International Food Information Council

The International Food Information Council (IFIC) foundation classifies food into five categories defined by the level of processing. The first category is called 'minimally processed', and are foods that require little processing or production, which retain most of their native properties. For example, foods like washed and packaged fruits and vegetables or roasted nuts and coffee beans. The second level is 'foods processed for preservation, nutrient enhancement and freshness', in order to reach its optimum in each category. This could be canned foods such as tuna, tomatoes, beans, fruits or vegetables, but also pureed and jarred foods. The third category is 'mixtures of combined ingredients' and are foods that contain sweeteners, spices, colors, flavors, preservatives and oils in order to promote safety, taste and visual appearance. This level includes foods such as cake mix, salad dressing and jarred tomato sauce. The next level is 'ready-to-eat processed foods', which need no or minimal preparation to consume. This includes, among other things, carbonated beverages, breakfast cereal, cookies, ice cream and yoghurt. The last category 'prepared foods/meals' includes foods packaged to preserve freshness and to facilitate preparation. For example, prepared deli foods, frozen meals and entrées such as pizza or chicken nuggets. [5]

2.1.1.3 Siga

The Siga classification was developed with the main objective to combine the four NOVA groups with additional subgroups, in order to consider the matrix of the food and ingredients; the quality of the added salt, sugar, and fat contents; the industrial and culinary food ingredients and its degree of processing; and lastly the level of potential health risk of additives. The Siga algorithm was then used to classify about 25 000 packaged foods in French supermarkets. [6]

The Siga classification can be divided into a ranking system, where foods are classified on a scale from the least to the highest processed food, with consideration to the degree and extent of food processing, which includes all ingredients and additives. The at-risk level of additives is based on the European Food Safety Authority (EFSA) and opinions from the French Agency for Food, Environmental and Occupational Health & Safety (ANSES), in addition with other newly scientific studies. The potential health risk of additives is included as a complementary evaluation of the ranking system. The Food Standard Agency (FSA) nutritional threshold values regarding the sugar, fat and salt contents are used. [6]

The first group on the scale is 'unprocessed foods' (A0), which are raw foods without any technological processing. It can be food items such as raw milk, fruit, vegetables, nuts, meat and eggs. The next level is 'minimally processed foods' (A1) and includes the 'culinary ingredients' (A2). The minimal processing covers cooking, grinding, fermenting, refining of for example grains, fruits, vegetables and meat. If not too processed, the culinary ingredients include among other things, butter, virgin vegetable oils, salt, table sugar and honey. However, refined and modified vegetable oils are considered as ultra-processed ingredients according to Siga, hence called markers of ultra-processing (MUP). In order to consider, the amount of added salt, sugar and fat content, four subgroups have been created. These are 'nutritionally balanced processed foods' (B1), which is below the FSA thresholds; 'high salt, sugar and/or fat level processed foods' (B2), which is above the FSA thresholds; 'nutritionally balanced ultra-processed foods level 0' (C0.1), which is below the thresholds; and 'high salt, sugar and/or fat level ultra-processed foods level 0' (C0.2), which is above the thresholds. [6] The last level of the ranking system is 'ultra-processed foods' at three different levels; C1, C2, C3, and is depending on the number of MUPs [7]. Ultra-processed foods are defined as products with at least one MUP, and the markers can be divided into two groups. The first group, MUP1, is derived from chemical synthesis identical to natural substances. For instance, natural flavoring, yeast extract, isolated protein or starches. However, MUP1 can also be obtained by stepwise processes leading to purification or if the food matrix undergoes a high deterioration. The second group is derived by artificial chemical synthesis and is called MUP2. It can also be obtained by stepwise processes that leads to combined purification and that the food matrix is significantly deteriorated. Some examples of MUP2 are glucose syrup, hydrolyzed proteins and carboxymethylcellulose. [6] As an overview, the Siga classification system consists of nine groups and is summarized in Table A-2 in Appendix.

2.1.1.4 Nutritional Database for Theoretical Calculations

The nutritional database used in this study for theoretical nutrient calculations originates from the Swedish Food Authority (SFA). The different food types are classified according to the European standard *LanguaL™*, which is the international framework for food description, and stands for "language of food". However, sometimes there is a lack of classifications for older food types. [8] The LanguaL™ system is an automated method in order to describe, capture and retrieve data about food, which works as a standardized language for information retrieval by classifying foods. More than 27 000 foods are included in the European LanguaL™ database. The framework is originating in the late 1970's by the Center for Food Safety and Applied Nutrition (CFSAN) of the United States Food and Drug Administration. Currently, the system is administered by its European LanguaL Technical Committee. [9]

2.2 What is the Common Consumer Perception of Processed Foods?

In an online study published in Uruguay 2016 performed by Ares *et al.*, the majority of 2 381 participants described 'ultra-processed' food as having lower nutritional quality, being unhealthy or containing artificial ingredients. This study investigated if the consumers' perception of ultra-processed foods was aligned with the NOVA classification, presented in section 2.1.1.1 above. The study concluded that the majority of the participants conceptualized the processed food products in agreement with it. Some of the participants in the study stated that the processed food loses all their nutritional properties because of processing, or that the nutritional quality decreased with increased number of processes, even though they could not name a source of information. The study highlighted the importance of including clear definitions of ultra-processed foods in educational campaigns, as well as including information about the ingredients and their nutritional properties. [10]

A qualitative study by EUFIC in 2016 in the UK, was performed through an online platform where the participants were asked questions related to their perceptions of processed foods prior being exposed to information. The questionnaire was being sent out once again six weeks later in order to investigate if the perceptions had changed. The study identified the lack of awareness among consumers in the UK regarding the benefits from food processing, such as improved food safety and nutrition. It also stated that participants accepted the processed food to a greater extent with increased familiarity. The study concluded that the participants' perception of the healthfulness of food products was inversely related to their level of processing. Meaning that some associated processed foods negatively in relation to a supposed loss of nutrients, and therefore, a loss of health benefits. [11]

A study in 2020 involving 1 500 adults done by IFIC and reviewed by Mitchell in 2021 concluded that consumers have an increasing awareness of processed food, which is the overall reason for consumers having a negative attitude towards it. The increasing awareness includes health problems such as obesity and heart disease, but also the questing for knowing what processed food contains which creates ingredient avoidance habits. This seems to drive the consumer perception, but also the spread of health scares publications which causes concerns. In this study, the authors claim that the scientific work in this area suggests that the impact on our health of processed food is very complex, and it would not be possible to avoid processed food in our diet as barely any food is unprocessed. Consequently, they state that processed food is a critical component of everyday diets. [12]

To summarize, the term 'processed food' is frequently used in a negative sense today. This is due to a general perception among people that industrially made food is nutritionally worse than homemade food, as a result of processing that occurs at food production sites. Processed food can also be misperceived as containing high fat, sugar and salt content, as well as loss of nutritional properties during the processing. As the food industry relies on the consumer acceptance, it is important to identify factors contributing to mistrust and rejections, as well as implementing educational marketing in order to inform consumers and to change their attitude towards processed food. This complex situation regarding the consumer perception of processed foods is the cause of the aim of this study.

It is important to be aware of that this study focuses on food processing in Sweden, while there is limited amount of collected information about Swedish consumers' perceptions. However, an indication on the incidence of this kind of concern for processed food among strong Swedish consumer groups can be found in the sale success of Mats-Eric Nilsson's books "The secret chef" and "Genuine product". The latter is called "The guide to pure food", where he discusses "How to find the genuine and pure foods", and how "We are fooled by the large grocery chains' ranges. It is rich in additives but poor in raw material." [13]

Moreover, a master thesis performed in Sweden by Könighofer in 2017 investigated the perception and the use of the term 'processed foods' in the society and in nutritional studies. The investigation was done through a literature study, but also by sending questionnaires to different target groups – students, people working in the food industry, and scientists. The survey showed that students had a general negative or neutral perception towards processed foods, and the people in the food industry claimed that consumers are negatively affected by the way processed food is portraited in media, as the term often is used incorrectly or in a confusing way. Lastly, the scientists had the perception that processed food affects the health, but they were not united in the question if the impact is positive or negative. In total, the answers of all three survey groups pointed towards the need of a clearer definition of the term 'processed food'. [14]

2.3 What Does Previous Studies Say About Differences in Nutrient Content and Healthiness When Comparing Homemade and Processed Food?

2.3.1 Benefits of Processed and Ultra-Processed Foods

As mentioned in section 2.1, different definitions exist regarding the term 'processed food'. Regardless of which definition, it is important to be aware of that processed food is not necessarily unhealthy in terms of high content of fat, sugar, salt or other less healthy additives. [15] A commentary done in the UK by Derbyshire in 2019 evaluated the NOVA classification system by analyzing 50 foods belonging to the definition of being 'ultra-processed', but also as 'healthy' classified by the UK Nutrient Profiling Model. The performance of this study was driven by the fact that ultra-processed foods often get the label of being "energy-dense, high in unhealthy types of fat, free sugars and salt, and poor sources of protein, dietary fiber and micronutrients", which is not always applicable for all modern food products. The authors state that categorization systems tend to focus on processing levels rather than nutritional profiles. The study found no statistically significant correlations between the number of ingredients and energy, saturated fat, total sugar, sodium, fiber and protein. Most of the identified ultra-processed foods were low in saturated fat and sugar, and a source of fiber. Additionally, approximately a third was low in in salt and a source of protein. The authors concluded that redundant definitions and overarching of ultra-processed foods might lead to avoidance by the public even though some ultra-processed foods might play a functional role in health. [16]

Unquestionable, some industrial products could have increased contents of fat, sugar, salt or additives, which make them less healthy than their unprocessed correspondent. Hence, it is important to be aware of the various food intakes in the diet. In addition to this, some people that are at risk of malnutrition could benefit from these types of energy dense foods in order to increase their intakes of calories. Nevertheless, processed food could help people meet their recommended daily nutritional intakes, by for instance fortifying the food with vitamins and minerals. One example of fortification is the addition of vitamin D in milk, which helps people achieve the recommended daily intakes. However, such techniques could mean that the product is categorized as processed or ultra-processed, which can have a negative impact on the consumers' perception of the food, even though it is only a classification, the method has positive benefits. Another example, where processed food plays an important role in people's diets, is when choosing alternative vegetarian or vegan products for meat, fish and dairy. These can also be categorized as 'processed' or 'ultra-processed', due to several processing steps. Moreover, another benefit with processing is the use of additives that can improve the palatability of the food, extend its shelf-life and improve the safety of the food. [15]

2.3.2 Current Knowledge

As stated in the background in 1.1, currently there is limited existing science based on evidence rather than valuations and beliefs, for the nutritional content in processed foods compared with homemade foods in Sweden. However, concerning already existing studies performed in other countries, it is important to remember that these studies do not necessarily apply to Swedish food production, and one should be careful and critical when making assumptions concerning the similarity. Therefore, there is a need for scientific-based evidence related to Sweden and its food industry.

2.3.2.1 Comparison Between Processed and Homemade Foods

A cross-sectional study was done in the UK by Howard *et al.* in 2012, with the objective to compare the nutritional content, in terms of energy and macronutrients, of ready meals from the three leading UK supermarkets with main meals created by television chefs. The study also compared both these values with nutritional guidelines from WHO and UK Food Standard Agency. The number of main meals was 100 randomly selected recipes from the top five books authored by television chefs and 100 randomly selected ready meals, that both met the inclusion criteria. The study concluded that the ready meals were more likely to comply with recommended carbohydrate and sugar intake, while the recipes were more likely to comply with the recommended intake of sodium. Notably, salt for seasoning was not considered. However, no ready meals or recipe complied completely with the WHO recommendations. Furthermore, the study concluded a significantly higher intake of protein, fat, saturated fat and energy in general for the recipes compared to the ready meals. Additionally, the result showed a significant difference in the fiber content per portion, where the recipes contained less fiber than the ready meals. [17]

The National Health and Nutrition Examination Survey (NHANES) is a program of studies that investigates the health and nutritional condition of adults and children in the US. The NHANES is a survey, and the nutritional condition is analyzed by combining interviews and physical examinations. The interviews consist of questions related to demography, socioeconomics, health, and the collection of dietary data. [18] By using this survey with data from the years of 2007 to 2010, a cross-sectional study in the US, performed by Wolfson & Bleich in 2015, investigated the diet quality and patterns in cooking frequency among almost 10 000 adults in the age of 20 and over. Diet quality was assessed based on daily intakes of energy, fat, sugar and carbohydrates, but also on the intakes of fast-food meals, frozen pizza and ready-to-eat meals consumed in the past 30 days. The study was based on dietary recalls and data from interviews, results were obtained through multivariable regression in order to examine the association between cooking frequency, dietary outcomes and intention to lose weight. The conclusion was that frequent home-cooking is associated with a healthier diet, whether or not if the purpose was to lose weight. [19]

Furthermore, a study was conducted in Scotland by Naruseviciute *et al.* in 2015, with the aim to investigate if homemade food is healthier than ready meals. This was done by comparing the nutritional properties of the ten most frequently purchased ready meals of Scottish households with their equivalent home-cooked meal. The homemade meal was matched by name of the ready meal and its main ingredients and taken from popular recipes in cookbooks or from the internet. The nutritional values were calculated with an analysis software, while the ready meals were taken directly from the declaration on the package. The study concluded that there were no significant differences between the homemade and the ready meals regarding energy, carbohydrates, fat, protein, short fatty acids, fiber or sodium when expressed per 100 g. [20]

Another study in the similar topic was published in the UK by Clifford Astbury *et al.* in 2019, where it was investigated whether a substantial consumption of homemade food is necessary for high dietary quality, or if it is possible to have a healthy diet while eating a small number of homemade foods. This comparative study was based on inadequate evidence regarding the relationship between home-cooking and a healthy diet. The study was done through a cross-sectional analysis of dietary data from surveys including food diaries for 4 days. The dietary quality was assessed using a scoring system from the Dietary Approaches to Stopping Hypertension (DASH) diet. These scores created groups of participants based on the energy proportion derived from the homemade food. The study concluded that home food preparation is not required in order to have a high-quality diet. [21] The DASH diet is an eating plan rich in fruits and vegetables, low-fat and non-fat dairy, along with nuts, beans, and seeds. It also includes lean meats, fish, poultry and whole grains. The DASH diet has been proven to lower blood pressure and cholesterol, as well as lower the risk of developing cardiovascular diseases, diabetes and several types of cancer. [22]

2.3.2.2 Processed Foods Connected to Health and Nutrition

A study published by Juul & Hemmingsson in 2015 investigated trends in consumption of ultra-processed foods in relation to obesity in Sweden, during the years of 1960 to 2010. The study analyzed changes in consumption of processed food by using data from the Swedish Board of Agriculture for Swedish adults from 18 years old. Additionally, it analyzed changes in obesity by using prevalence data from peer-reviewed literature, Statistics Sweden and WHO Global Health Observatory. The study concluded that the subjects' consumption of ultra-processed food had increased dramatically, along with increased obesity prevalence. Nevertheless, the study encouraged more future research in order to clarify the potential causality. [23]

A study published in the US by Weaver *et al.* in 2014 used the NHANES survey to perform analyses from studies between 2003 and 2008 which showed that processed foods contribute with nutrients that are encouraged in the diet, as well as the ones to limit. Which nutrients to encourage and to limit originated from the American dietary guidelines. In relation to the recommended daily intake for Americans, the processed foods contained 55% of dietary fiber, 48% of calcium, 43% of potassium, 34% of vitamin D, 64% of iron, 65% of folate and 46% of vitamin B12, from the nutrients to encourage. The nutrients to limit were contributed by 52% of saturated fat, 75% of added sugars and 57% of sodium. The processed food did also contribute with 57% of the daily energy intake. The conclusion from these results was that the choice of unprocessed or processed foods did not matter in order to meet the food guidance recommendations, as long as they were nutrient-dense. [24]

A study was conducted in the US by Poti *et al.* in 2015, with the objective to determine trends from year 2000 to 2012, in the degree of food processing and level of convenience. Thereafter, comparing the content of saturated fat, sugar, and sodium across the different levels and degrees. The number of investigated households were 157 142 with over 1.2 million classified products. The study concluded that highly processed food i.e., multi-ingredient industrially formulated mixtures, and ready-to-eat foods dominated the purchase pattern of US households during the given time span, and may contain more saturated fat, sugar and sodium than less processed foods. [25]

Another study by Moubarac *et al.* in 2017 investigated the association between consumption of ultra-processed foods and the diet quality in Canada. It was accomplished by using the NOVA classification and 24 hours dietary recall intakes of 33 694 participants aged two years and above, taken from the 2004 Canadian Community Health Survey. The intake of nutrients was calculated by using quantities and nutrient values for each food item. The study showed that 39.2% of the food consumption in Canada was from unprocessed or minimally processed foods, 6.1% from processed culinary ingredients, 7.0% from processed foods, and lastly 47.7% from ultra-processed foods. The study concluded that non-ultra-processed foods had better nutritional values than ultra-processed foods as a group. A significant reduction of the contents in protein, fiber, vitamin A, C, D and B12, niacin, thiamine, riboflavin, zinc, iron, magnesium, calcium, phosphorus and potassium occur once the dietary intake of ultra-processed foods increases, which is accurate for both non-adjusted and models adjusted for covariates. Furthermore, adjusting for covariates showed a significant contribution to energy density, carbohydrates, free sugars, total and saturated fats derivates from ultra-processed foods. [26]

A similar study from the US by Martínez Steele *et al.* in 2017 investigated the overall nutritional quality in relation to the share of ultra-processed foods using the NOVA classification and the dietary intakes of 9 317 individuals from the NHANES, aged one year and above. From the contribution of ultra-processed foods, the study showed a significant reduction of protein, fiber, vitamin A, C, D and E, zinc, magnesium, calcium and phosphorus, while a significant increase of carbohydrates, free sugar and saturated fat. [27]

A study performed at the University of Washington in the US by Gupta *et al.* in 2019 characterized ultra-processed foods by using energy density and nutrient density. This was done by assigning 384 foods originating from the Fred Hutchinson Cancer Research Center (FHCRC) food frequency questionnaire to four different NOVA categories (ultra-processed, processed, unprocessed and culinary ingredients) and to seven different USDA MyPyramid food groups (dairy; meat, poultry and fish; beans, nuts and seeds; grains; fruit and juices; vegetables; and fats and sweets). The nutrient density was calculated using the Nutrient Rich Food 9.3 (NRF9.3) index, which specifies nine nutrients to encourage and three nutrients to limit. The result showed that 50% of the foods classified as ultra-processed had lower NRF scores, while unprocessed ones had higher scores. However, some of the ultra-processed foods had higher NRF indices. The study concluded that ultra-processed foods seem to have higher energy density and to be poorer in nutrients, as compared to unprocessed food. [28]

A similar study published in the US by Drewnowski *et al.* in 2020 examined the relation between NOVA classifications and NRF indices in order to investigate the possible overlap for ultra-processed foods. This was done for 378 foods, also coming from the FHCRC. The NRF indices were based on a positive sub score consisting of protein, fiber, vitamins and minerals contents, as well as the negative sub score based on saturated fat, added sugars and sodium content. While the NOVA classifications were mainly based on the saturated fat, added sugars and sodium contents of the foods. The study found correspondences between the NOVA classification and the NRF indices concerning the nutrients to limit. A higher nutrient density, i.e., a higher NRF index, was found to have less impact on the NOVA classifications. The authors concluded that the NOVA categories just added a little, and that the health outcomes could have been obtained by using only the NRF indices instead. [29]

A cross-sectional study by Andrade *et al.* in 2021 investigated the association between ultra-processed food consumption and nutritional diet profile among French adults. The study involved 2 642 adults and collected dietary data through three 24 hours dietary recalls, and the data was classified according to the NOVA classification. The data was analyzed for the association between the part of ultra-processed food in the diet with nutritional indicators by using linear and logistic regression. The study concluded that the consumption of ultra-processed food had a positive correlation with the dietary contents of total carbohydrates, free sugar, total and saturated fat, as well as with the energy density in the dietary intake. It also concluded that it was positively associated with inadequate dietary intakes of, saturated fat, free sugar and fiber, as well as inadequate energy density. [30]

Another study by Sadler *et al.* in 2021 examined the basis of classification systems of processed food by providing a critical analysis. The analysis was based on purpose of the classification, scientific foundation and definitions of the categories. This was done by literature review including 470 publications where definitions of processed foods were screened for. The aim with the study was to investigate the underlying concepts of the classification systems. One of the major findings of the study was that most of the systems expressed concerns about the public consuming more industrially made food due to increased risk of chronic diseases. The study also compared foods produced industrially and at home, where they stated that many processing methods such as cooking, drying, salting and fermentation take place at both locations. The authors contrasted by saying that this might imply that some of the critique towards processed food should be valid for homemade foods too in some cases. However, the study summarized the importance of understanding the outcomes of processing related to health, both concerning foods made in the industry and at home, in order to provide an evidence base for this nutritional comparison. One of the conclusions of the study was that processing and nutritional values of the food do not have a linear relationship, and that the classification of processed food needs further explanation in order to support the consumer understanding. [31]

2.4 Theoretical Nutritional Changes in Food

Food is biological material where various physical, chemical, biochemical and microbiological reactions can lead to nutritional losses, but also gains. However, as mentioned in section 1.4 about delimitations, the bioavailability of nutrients will not be investigated, in other words, how different preparation methods can affect a nutrient's ability to be absorbed into the body. This section describes the nutritional changes in food during handling and processing.

2.4.1 During Processing

In general, when it comes to preparation of food, nutrient content is affected the least when cooking time is short, temperature is low and with little fluid present. The suggested most gentle method for home cooking is steam cooking, followed by cooking in microwave, boiling, and then stir-frying or frying. [32] Furthermore, since many food processes may cause losses of nutrients, some foods can be fortified in order to fulfill its original nutrient contribution.

2.4.1.1 Fat

When frying or cooking food, the fat content may decrease due to that fat can melt out, hence end up in the pan or in the boiling water. This means that the energy content will decrease too, and losses of essential fatty acids and fat-soluble vitamins may occur if the cooked product contains these. [33] Furthermore, the nutritional content of vegetable oils can be altered by heating, where polyunsaturated fatty acids deteriorate and saturated and trans fatty acids are formed. However, literature complied by the Technical University in Denmark indicates that a very limited amount of trans fatty acids is formed during normal frying. Even for the most sensitive oils, heating above 200°C for more than four hours, is required for the trans fatty acid content to reach even 2%. [32]

2.4.1.2 Protein

The main factors that affect proteins in food are frying, cooking, high salt or sugar content, low pH, strong mechanical impact or dehydration. These factors lead to denaturation of proteins, where cohesive bonds in the protein and peptide chains are straightened. However, denaturation does not alter the protein nutritional value. When denatured, the digestive enzymes in the gastrointestinal tract can more easily cleave the free peptide chains resulting in loss of three-dimensional structures. Furthermore, chemical reactions between amino acids and reducing sugars, also called Maillard reaction, can occur in all heat treatments, which may lead to a lower protein content in the food due to formation of other compounds. [33] Most food protein denaturation occurs when exposed to heat treatments between 60°C and 90°C for one hour or less. Additionally, the protein content can be lowered by several unit operations, such as extraction, filtration and isoelectric precipitation where the proteins can be extracted during these procedures. [34]

2.4.1.3 Carbohydrates

When heating food that contains sugars, mono and disaccharides can be dissolved in the cooking liquid due to water solubility. Heating above 100°C will result in that some of the starch is broken down into dextrins. Furthermore, when the temperature becomes even higher, Maillard reaction or caramelization can occur. These reactions result in that carbohydrates become inaccessible for humans, and some toxic compounds may be formed; hence the energy content decreases. However, only small changes occur in the nutritional value of starch during normal food preparation. Additionally, cooked starch has the ability to form resistant starch, which can be counted as dietary fiber. [33] Dietary fiber is a wide variety term for plant-based carbohydrates that are not digested in the small intestine and therefore, are reaching the large intestine and colon. Dietary fiber can generally be categorized into two groups, soluble and insoluble fiber. [35] However, the fiber content within food is not altered during cooking, chopping or blending, but is rather lowered in procedures like peeling and removing of seeds. [36]

2.4.1.4 Vitamins and Minerals

Vitamins are unstable in foods, as processing and cooking cause losses of vitamins. However, it is difficult to draw any conclusions regarding the nutritional changes as the reduction varies widely depending on the cooking method and the type of food. [37] The losses vary with the vitamin's sensitivity to oxidation through the influence of oxygen, but also to light, heat, acidity and the presence of catalysts and antioxidants. An additional effect is the vitamin's tendency to dissolve in water or fat, where water-soluble vitamins can leach out and be dissolved in the boiling water. Therefore, optimal processing of food should take place in as little water as possible. Furthermore, short time and low temperature are advantageous in order to minimize the loss of vitamins. [33] In general, the most heat sensitives vitamins are vitamin C, thiamin and folate. [37]

The most comprehensive information on cooking losses for minerals and vitamins can be found in a systematic review of retention factors for different food categories and cooking methods. The retention factor indicates the proportion of nutrients that remains after cooking, and a lower retention factor implicates a larger loss. Table A-3 in Appendix shows the retention factors for some nutrients, where values ≤ 0.6 are marked with bold, indicating a low retention factor, thus, a large loss. [38]

In overview, the sensitivity of nutrition losses of vitamins is that vitamin A (retinoids and carotenes) is affected by oxidation, at especially high temperatures, but is comparatively stable under atmospheres where oxygen is excluded. Vitamin D is relatively stable when it comes to oxidation but is susceptible to light, alkaline pH range and heat. Nevertheless, there is limited data in order to give an adequate relationship between the preparation methods and the nutritional changes. However, it seems like the fat content is a crucial factor affecting the retention of vitamin D, as a high fat content might result in a high vitamin D reduction. On the contrary, a low-fat content may make vitamin D more easily accessible for aggressors by disruption of thermal isolation. As for vitamin C, the losses occur mainly through leaching and oxidative degradation. The losses are affected by any factor that facilitates oxidation such as, the degree of heating, the amount of boiling water, the surface area exposed to oxygen and water, the pH and the presence of transition metals. Moreover, thawing frozen vegetables before cooking causes a higher loss of vitamin C. As for folate, the loss is affected by thermal degradation and leaching into the boiling water. In addition, it can be affected by cooking at low pH, oxidation and by antioxidants. [37]

When it comes to minerals; heat, light, oxidizing agents, extremes in pH and other factors that affect organic nutrients will not degrade minerals, unlike vitamins and amino acids. However, minerals, such as salt, can be removed from foods by leaching or physical separation, where milling is the most important causing mineral loss in food, especially for cereals. [39] Also, potassium is the only mineral where leaching happens in such an extent that is has practical significance. [32]

2.4.2 During Microwaving

As mentioned above in section 2.4.1, microwaving is the second most gentle method in terms of destroying nutrients in foods and therefore preserving the nutritional content. Despite the building up of heat energy due to vibration of water and other electrically asymmetrical molecules, the shorter cooking time creates a better preservation of the nutrients instead of breaking them down. Additionally, as microwaving is a preparation method which does not involve any additional cooking liquid, it also retains nutrients as no leaching occurs. Therefore, it can be advantageous to prepare food in the microwave in terms of maintaining the nutritional content considerably. [40]

2.4.3 During Freezing

In general, the preservation of food by freezing results in high-quality products for consumption, but the quality varies depending on the freezing process and storage conditions. Preservation depends on several mechanisms, such as the microorganism's growth rate, which is significantly reduced due to temperatures below 0°C as well as the formation of water ice crystals within food that makes it less available for biochemical reactions that can deteriorate the food. [41]

Freezing is a good way for preserving nutritional values in foods, but the values can change during freezing depending on the nutrient, the type of food, the freezing rate and time. Additionally, freezing methods provide better quality of the foods compared to other preservation methods. One of the main concerns regarding nutrient loss associated with freezing is related to the blanching process that often occurs prior to freezing of mainly vegetables in order to deactivate enzymes, which can degrade heat sensitive nutrients. [42] Nevertheless, there is only a minor nutrient loss during the freezing process, but the storage time can have a large impact.

2.4.4 During Storage

Regarding the loss of quality when food is stored frozen, it is mainly affected by storage temperature, storage time and thawing procedure. A storage temperature of -18°C inhibits microbial growth entirely, and it also significantly slows down the rate of enzymatic and non-enzymatic changes. [43]

In general, carbohydrates are stable during storage, with no significant losses in nutritional value in neither frozen, dried nor canned foods. In proper conditions, protein is also not affected by storage significantly. Fat on the other hand, may undergo deterioration of its quality during long storage time due to oxidation and hydrolytic rancidity. As for changes in vitamins and minerals during storage, they vary depending on the food, the nutrients and the conditions, such as sunlight exposure, moisture content and temperature. [44] For example, losses of vitamin C occur during freezing and frozen storage mainly due to oxidation. [43]

2.4.5 Other Sources of Variation

All foods will inevitably undergo some loss of nutrients, which begins at the time of harvesting. The nutritional values of foods vary, where the concentration of vitamins in vegetables and fruits varies depending on the maturity stage, the cultivar genetics characteristics, the climate, and the growth site. Furthermore, the vitamin content is also altered during maturation of fruit and vegetables as a result of the rate of synthesis and degradation. For example, studies show a 35% reduction of folate in tomatoes during ripening. Another study showed no significant influence of carotenoid content in carrots by the stage of maturity but varied significantly with the variety within carrots. When it comes to the vitamin content of animal products, it is determined by biological mechanisms and the animal feed. Moreover, post-harvest changes in vitamin content can occur due to enzymatic activities in fruits and vegetables, but also post-slaughter changes in tissue of animals, which may cause changes in vitamin activity. These changes are inevitable but can be minimized by appropriate handling after harvesting or post-slaughter. [45]

Regarding the mineral composition of plant foods, it can also vary greatly due to plants obtaining essential mineral nutrients from soil via the roots. Consequently, the mineral content is also affected by the plant genetics characteristics, the soil fertility, the climate, and the growth site. As for animal foods, the mineral content varies less than plant foods. However, it can be slightly affected in meat, milk and egg by the animal's dietary intake. [39]

Meat is a good source of protein, variety of fats, zinc, iron, selenium, potassium, magnesium, sodium, vitamin A and folic acids. However, the composition of these nutrients varies depending on different factors, such as the type of meat source, but also due to the type of feed (grass, grains or pasture), genetics of the animal and different postmortem techniques. The average protein value in meat is around 23% but varies depending on the previously explained factors. Additionally, the fat content can vary greatly due to these factors as well, but also within animals' parts. The fat content can have a range from 8 to 20% in animal carcasses. [46]

In short, fresh fruits and vegetables, when harvesting, continue to undergo chemical changes which can lead to deterioration of the food. This results in a continuous breakdown of nutrients within the product. Thus, these should be frozen as soon as possible after harvesting in order to reach the peak degree of ripeness. [47]

2.5 Swedish Dietary Guidelines and Recommendations

According to the SFA, the official Swedish dietary guidelines are originating from the Nordic Nutrition Recommendations (NNR) 2012. In general, the importance lies in the completeness of the diet. This means having a balance, which can be obtained by eating a variety of foods and not in excess, in combination with physical activity. [48]

According to the NNR 2012, some general dietary guidelines can be established in the Nordic countries from conclusions drawn from documented health risks related to the diet; the first one being to decrease the energy density, increase the nutrient density and improve the carbohydrate quality. The second one is to improve the fat content in the diet by balancing the intake of different fatty acids. The third one is to limit the intake of processed and red meat, and the last one is to limit the use of salt in foods and when cooking. [49]

2.5.1 Macronutrients

The NNR 2012 gives recommendations regarding the daily intake of macronutrients, and how these should contribute to the total energy intake. Regarding the intake of fat, there is more scientific evidence stating the importance of how to balance the consumption of different fatty acids, rather than how the total fat intake should be regulated. This is in relation to how different fatty acids can affect the health, and the development of cardiovascular diseases, diabetes and cancer. The same kind of recommendation is valid for carbohydrates, where foods containing fiber and wholegrain are related to positive health effects while foods containing refined cereals, white flour and added sugars are related to negative ones. To conclude, in relation to health, the intake of subgroups of fat and carbohydrates are more relevant than the total ones. The recommended daily intake (RDI) of macronutrients for adults is summarized in Table A-4 in Appendix. [49]

2.5.2 Micronutrients

The RDI of micronutrients, vitamins and minerals, are specified by the NNR 2012. The recommendations constitute a well-balanced and varied diet, optimal physiological functions with the reduction of diet-related disease risks. According to the dietary patterns in the Nordic countries, it has been shown that focus in the nutritional recommendations should be partly given to certain micronutrients such as vitamin D, sodium, iron and folate. The recommended daily intake of micronutrients for adults in the age of 18-30 years is summarized in Table A-5 in Appendix, where the chosen age interval is based on the age of the test subjects. [49]

2.5.3 Energy Intake and Physical Activity

The energy intake should be in balance with the energy expenditure in order to avoid long-term negative health effects. Therefore, the energy intake should not be too high nor too low. This balance is individual depending on factors such as gender, weight, physical activity and age [49]. The physical activity level (PAL) can be formulated by using a score, which is represented by the mean value of the intervals of each lifestyle classification, which can be seen in Table A-6 in Appendix. An active lifestyle corresponds to a PAL of 1.8, while 1.6 is represented by a sedentary work with a somehow increased activity level during the free time. [50]

In order to estimate the energy requirement for a person per day, the PAL value is multiplied with the estimated basal metabolic rate (BMR). BMR is estimated using equations based on gender and age, which can be seen in Table A-7 in Appendix. [50] The PAL value is individually estimated by each test subject, which generates the BMR value in order to use it for the analysis of the energy intake related to the portion size each subject plate on a normal basis.

2.6 Nutrient Rich Food Index

The Nutrient Rich Food (NRF) Index is a ranking system used to give scores to foods based on their nutrient density, i.e., nutritional content, which can be used to distinguish affordable foods with optimal nutrition. The nutritional aspect is built on recommendations on what nutrients to ingest, where the NRF9.3 Index includes 9 nutrients to encourage (protein, fiber, vitamin A, vitamin C, vitamin E, calcium, iron, magnesium and potassium) and 3 nutrients to limit (saturated fat, added sugar and salt). As the NRF Index is calculated as the sum of the percentage of the daily recommended values of the nutrients to encourage, minus the sum of the percentage of the maximum recommended values of the nutrients to limit; a higher NRF score is associated with more nutrient-dense foods. [51] Consequently, the NRF Index can be a proper way of reporting the results, when comparing the nutritional content in processed and homemade foods.

2.6.1 Modified NRF Index

In order to comply with the Swedish dietary guidelines, an NRF Index adapted to Sweden has been created. This index includes 11 nutrients to encourage and 3 nutrients to limit and is therefore called a Sweden-tailored NRF11.3 Index, shown in Table 2-1 and Table 2-2 below. The two added nutrients to encourage are vitamin D and folate, as these are nutrients of key concern for the Swedish population. A study by Bianchi *et al.* in 2020 showed that NRF11.3 was coherent with the Swedish dietary guidelines and showed that nutrient density is a proper indicator of food quality and how to make healthy dietary choices. This was shown as the index promoted most healthy foods for the high nutrient densities, and unhealthy foods for the lower nutrient densities. [52]

It is decided that the same algorithm for calculating the NRF11.3 index is to be used in the study, since it was concluded that the index was flexible in the choice of nutrients and to use different reference amounts, as well as easy to adapt to the RDI values. The equation is shown below in Eq. 1, where x is the number of nutrients to encourage, and y is the number of nutrients to limit, *Nutrient i/j* stands for the content of *Nutrient i/j* per reference unit of the food product, *RDI* is the recommended daily intake of the nutrient i to encourage (if there is an interval, the minimum value is used), and *MRI* is the maximum recommended intake of nutrient *j* to limit. The values for the RDI and MRI are shown in Table 2-1 and Table 2-2 below and are taken from Table A-4, and Table A-5 in Appendix, originating from NNR 2012. [52] The values for the micronutrients are based on an average value between adult women and men (18-30 years old), and the macronutrients are based on a 2000-kcal diet.

TABLE 2-1. RDI VALUES FOR THE MODIFIED NRF INDEX.

	Nutrients to encourage - RDI									
Protein	Fiber	Vit A	Vit C	Vit D	Vit E	Folate	Calcium	Iron	Magnesium	Potassium
49 g	25 g	800 RE[a]	75 mg	10 µg	9 α-TE[b]	350 µg	800 mg	12 mg	315 mg	3.3 g

RDI = recommended daily intake.
a. 1 retinol equivalent (RE) = 1 µg retinol = 12 µg beta carotene.
b. 1 α-tocopherol equivalent (α-TE) =1 mg RRR-α-tocopherol.

TABLE 2-2. MRI VALUES FOR THE MODIFIED NRF INDEX.

	Nutrients to limit - MRI	
Saturated fat	Added sugar	Salt
22 g	49 g	6 g

MRI = maximum recommended intake.

Eq. 1
$$NRF_{x.y} = \sum_{i=1}^{x} \frac{Nutrient\ i}{RDI_i} \cdot 100 - \sum_{j=1}^{y} \frac{Nutrient\ j}{MRI_j} \cdot 100$$

2.6.2 Reference Unit

The choice of reference unit for calculating the NRF11.3 index may impact the outcome in different ways. The three different reference units to use are per 100 g, per portion and per 100 kcal. A study by Drewnowski *et al.* in 2009 tested if nutrients profiling should be based on 100 g, 100 kcal or the portion size by ranking 378 different consumed foods from a food frequency instrument and evaluating the performance. The results showed that the correlation between the NRF indices based on 100 kcal and on portion was higher than the correlation between the indices based on 100 g and on portion. In addition, scores based on 100 g underestimated the nutrient values of foods consumed in amounts larger than 100 g, while being advantageous to nutrients to encourage if these were consumed in amounts less than 100 g. The study concluded that NRF indices based on 100 kcal and portion size are preferable to use to positive subscores, i.e., the nutrients to encourage, while the indices based on 100 g were preferable to negative subscores, i.e., the nutrients to limit. [53]

Another study by Bianchi *et al.* in 2020 investigated the different impacts of these reference units by evaluating the nutrient density of foods. The authors' rationale for including per 100 g was due to its consistency with the EU food labeling, per 100 kcal due to its benefits for low-energy dense foods, and per portion due to its facilitative way to inform the consumer. The results pointed at that the choice of reference unit played the largest role in impact on the NRF index, rather than the choice of what nutrients to include and exclude. Concerning the NRF11.3 index, the study concluded that the reference units based on energy or weight, i.e., per 100 kcal or per portion, were the most suitable ones to apply. [52]

3 Ready Meal Products

3.1 Inclusion Criteria

Some inclusion criteria were applied for the selection of the ready meal products. These are to have a relatively low complexity of the dish, in order to minimize the difficulties in imitating it, the ready meal dish should also be conceptual, meaning that it should be relatively "well-established" in order to facilitate the selection for corresponding home recipes. Additionally, the ready meal product should represent a relatively popular dish among people in Sweden, as this project is limited to the Swedish market and its consumers. Since more than one dish is investigated, the dishes should differ in their level of processing and the content.

3.2 Selection

According to the inclusion criteria above, three ready meal products were chosen: **Felix Classical meatballs**, **Felix Potato mash** and **Felix Fettuccine Bolognese**. The meatballs were chosen as this is a popular dish among consumers in Sweden, its target group is wide, and the raw material and the final product are more similar compared to the other ones. On the contrary, the potato mash represented a product where the raw material is different from the final product, due to several processing steps. Additionally, potato mash is a popular side dish to eat together with meatballs. Note that these two products were investigated separately and not together, although it is not uncommon to combine these two into a meal. The fettuccine bolognese was chosen as investigation into one complete meal is wanted, and it is also a popular dish among consumers in Sweden.

According to a survey from Food & Friends conducted in Sweden 2020, involving a representative sample of 1025 people; spaghetti bolognese and meatballs with a side dish became two of the most popular dishes for Swedes to eat during weekdays. The 10 most popular weekday meals constitute 58% of the total, where the spaghetti bolognese was the most popular dish representing 11.2% out of these, and the meatballs with a side dish represented 4.1% out of these [54]. This indicates that the chosen dishes are three popular food types among consumers on the Swedish market.

The chosen products are referred to as the **control products**. Some product information about the three ready meal products is shown in Appendix A.2.1, where the nutrition values per 100 g can be found, presented by Orkla Foods.

3.3 NRF Nutrients to Include and Exclude

For each ready meal product, there is a set of nutrients that were analyzed for the content. The nutrients available to choose from were based on the 14 nutrients from the modified NRF Index, presented in Table 2-1 and Table 2-2. The reason for excluding some nutrients was to have an economical approach and to reduce the expenses where it is possible. Additionally, it is redundant to analyze nutrient levels if they are approaching zero, as the results will not show anything. These values were set to zero in Eq. 1. The inclusions and exclusions are shown below in Table 3-1, where the nutrients to limit are marked with bold text.

As seen below in Table 3-1, dietary fiber was excluded from the meatballs as that dish do not contribute with any carbohydrate source, like the potato mash and pasta bolognese do. Vitamin C was excluded, and iron was included in the meat-containing dishes, as vitamin C is more related to plant-based and iron to animal-based food. On the contrary, vitamin C was included, and iron excluded in the potato mash, as this dish is vegetable-based. Vitamin E was excluded from all three dishes, as they all are poor in sources contributing with it. Added sugar was also excluded from the external analysis, but it is related to the amount of sugar added and was calculated instead. Folate was excluded in the meatballs, as this dish do not contain sources contributing to the folate content.

TABLE 3-1. NUTRIENTS TO INCLUDE AND EXCLUDE IN THE ANALYSIS.

Ready meal product	**Nutrients to include**		**Nutrients to exclude**
Meatballs	Protein Vitamin A Vitamin D3 Calcium Iron	Magnesium Potassium **Saturated fat** **Salt** **Added sugar**	Dietary fiber Vitamin C Vitamin E Folate
Potato mash	Protein Dietary fiber Vitamin C Vitamin D3 Folate Calcium	Magnesium Potassium **Saturated fat** **Salt** **Added sugar**	Vitamin A Vitamin E Iron
Pasta bolognese	Protein Dietary fiber Vitamin A Vitamin D3 Folate Calcium	Magnesium Potassium Iron **Saturated fat** **Salt** **Added sugar**	Vitamin C Vitamin E

4 Experimental Planning

4.1 Factors

Two different areas related to the manufacturing of food, that possibly could influence the nutritional content are defined below in Table 4-1. The two chosen areas are the **method** and the **equipment**, which are called experimental factors. The formulated definitions of these factors are shown below in Table 4-1.

TABLE 4-1. DEFINITIONS OF EXPERIMENTAL FACTORS.

Experimental factor	Definition
A: Method (Raw material and recipe)	It refers to the content of the food and how it should be cooked, with belonging specifications such as time and temperature. In other words, the raw material and recipe.
B: Equipment (i.e., production scale)	Based on where the food is produced, that is, in an industry or at home. These two environments have access to different kinds of equipment and machines in different scales.

4.1.1 Combinations of Factors

Each factor can be varied on two levels: industry (I) or home (H). Therefore, these two factors can be combined in four different ways. However, combining the home method and the industrial equipment was excluded as it is not possible to produce something in the factory, except the control product (industry/industry). The factors generate three treatments shown below in Table 4-2, where μ is the resulting nutritional value. One value for μ is generated for each nutritional value of interest, and for each treatment. The three treatments are visualized below in Figure 4-1.

TABLE 4-2. COMBINATIONS OF FACTORS ON TWO LEVELS.

		Factor B: Equipment	
		I	H
Factor A: Method	I	μ_{II} (control)	μ_{IH} (1)
	H	$\cancel{\mu_{HI}}$	μ_{HH} (2)

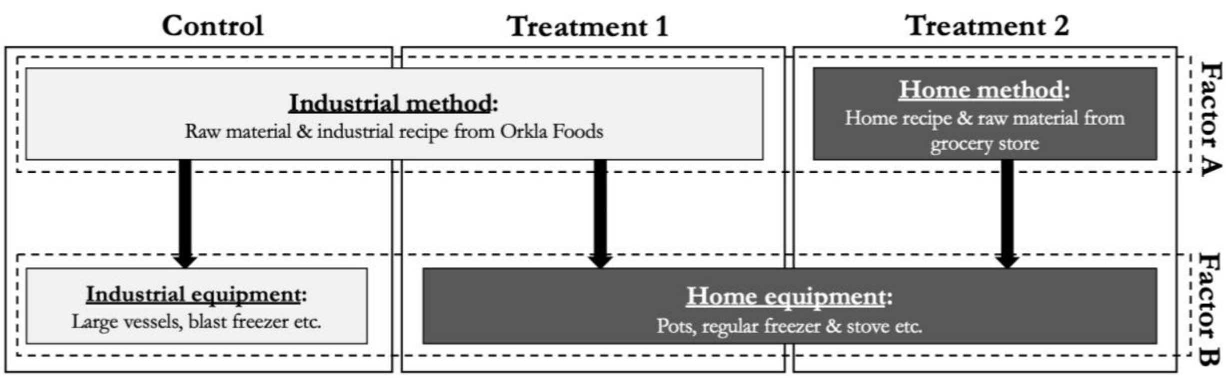

FIGURE 4-1. TREATMENTS.

The first combination is called **Control** and refers to that the food is entirely related to the industry. This means that it has been produced by using an industrial method, i.e., industrial recipe and raw material from Orkla Foods, with equipment found in the industry, i.e., in a factory. This can be called an inactive treatment, since it is the control product. The second combination is an active treatment, and it is called **Treatment 1**. The food is produced using the industrial recipe and raw material from Orkla Foods, but with equipment found in a home kitchen. The third combination is an active treatment, and it is called **Treatment 2**. It is entirely related to the home, both the method, i.e., a home recipe and raw material from the grocery store, and home equipment.

4.1.2 Comparisons of Treatments

The three treatments above generate three comparisons, presented in Table 4-3 below. Concerning the first and second comparison, it might be possible to receive information about the factor not in common, as this is what separates the combinations. The third comparison focuses on a general difference between processed and homemade foods. As both factors are included, it will not be possible to derive the potential difference to a certain factor.

TABLE 4-3. COMBINATIONS OF FACTORS.

Comparison	Causing the potential difference
Treatment 1/treatment 2	Factor A: raw material and recipe.
Control/treatment 1	Factor B: production scale and equipment.
Control/treatment 2	Factor A + B

4.2 Number of Replicates

The number of replicates, i.e., the number of test subjects, that perform the cooking of treatment 1 and 2, was determined using the variation within a treatment. This was considered for the significance of the results in the hypothesis testing, described in the following sections.

4.2.1 Hypothesis Testing

For the hypothesis testing, a null hypothesis H_0 and an alternative hypothesis H_1 was formulated. The testing was done for a difference Δ between the resulting nutritional value $\bar{x}$ from the 'homemade' meals, and the value μ_0 from Orkla Foods's ready meal product. H_0 represents a difference of zero, and H_1 represents a difference not equal to zero. The strength of the hypothesis testing makes it possible to reject the null hypothesis if it is actually false. The higher the number of replicates, the higher the strength of the hypothesis test.

Null hypothesis H_0: $\Delta = 0$ | **Alternative hypothesis** H_1: $\Delta \neq 0$ | $\Delta = \bar{x}-\mu_0$

4.2.2 Power Analysis

In order to assess the power of the hypothesis test, the size of the effect was investigated. This is usually done with previously performed experiments, in order to determine the number of replicates for future experiments. Since previously conducted experiments within this area are lacking in Sweden, that equals a lack of already documented representative nutritional values for the home-cooked meals.

To investigate the power, a two-sided t-test was used, shown in Eq. 2 below. This t-test investigates what size the difference $|\bar{x}-\mu_0|$ between two samples must be in order to discover this difference, with the number of replicates *I* and the standard deviation *s*. The mean value $\bar{x}$ and the standard deviation *s* both refer to the homemade meals, while μ_0 refers to the nutritional value from Orkla Foods. Z is the test variable related to the standardized normal distribution, calculated by using the significance levels α and β, which are set to 5% and 20% respectively.

Eq. 2
$$I > \frac{s^2}{(\bar{x}-\mu_0)^2} \cdot \left(z_{\frac{\alpha}{2}} + z_\beta\right)^2 + \frac{1}{2} \cdot z_{\frac{\alpha}{2}}^2$$

In order to change the approach, a fixed value for *I* was set, and the difference $|\bar{x}-\mu_0|$ was expressed in terms of the standard deviation, shown below in Table 4-4, for different values of *I*. This gave an indication on the size of the difference for a nutritional content, between the treatments, in relation to the standard deviation. A higher number of replicates 'allows' the mean of the treatment to approach the reference value, which is shown with less standard deviations. This means that a smaller difference is more likely to be discovered, the more replicates used.

TABLE 4-4. NUMBER OF REPLICATES IN RELATION TO STANDARD DEVIATION.

Number of replicates *I*	**3**	**4**
Difference ($\bar{x}$-μ_0)	±2.7s	±1.9s

The chosen number of replicates was 4 since it was unknown how much the variation in the homemade meal would actually affect the resulting nutritional values, as previous experimental results were lacking. Therefore, it was wanted to have some margin in order to have a higher probability of obtaining significant results after the performance of the set of experiments.

4.3 Home Recipes

An essential part of the experimental planning, which creates the foundation for the practical work, was the selection of the home recipes which the test subjects follow during the home cooking, i.e., for treatment 2 where the home method and the home equipment will be investigated. The question to ask when searching for the home recipe was: "What would I cook at home instead of buying this ready meal product?". The desire was to find the most conceptual and widely used recipe for home cooking among people in Sweden in order to use a recipe as representative as possible.

The ready meal product 'Fettucine Bolognese' is referred to as 'pasta bolognese', as it is the amount of pasta that matters in this context, rather than the type of it. This is mentioned in order not to confuse the reader by using two different terms.

4.3.1 Variation Analysis

10 different home recipes of each dish were selected based on the number of ratings online, in order to make a well-established decision. It was assumed that the number of ratings can be an arbitrary measure of the number of users. The recipes should be designed for approximately 4 persons and the similarity of the content is taken into consideration. Additionally, some widely used Swedish cookbooks were used in order to reach the number of 10 recipes. These recipes were compared in order to get an estimate of the variation between them. In short, the variation analysis was conducted by comparing the mean nutritional values in all recipes, by using the nutrient values from SFA and the LanguaL™ database presented in section 2.1.1.4. The result showed that the different recipes had a relatively low variation, and the recipe content should not affect the outcome notably regardless the choice of it. Therefore, it was concluded to choose the recipes having nutrient values closest to each median value. The median value was chosen as it is less sensitive to outliers in the data and more robust than the mean value.

Table A-12 in Appendix shows the two recipes with the highest percentage of median-comparable nutrients and ratings, for all nutrients and for the NRF nutrients. Both the percentage and the number of ratings was considered for the choice of recipe. Hence, recipes 2, 3 and 6 were chosen, which are marked in bold.

4.3.2 Contents in Recipe

The chosen home recipes are presented below in Table 4-5, including the source of the origin. The chosen brands for each ingredient can be found in Table A-13 in Appendix. As for the meatball recipe, minced meat of both beef and pork, and butter was chosen. The cooking oil used for the pasta bolognese, was chosen to be rapeseed oil. The contents below represent one cooking session, i.e., one replicate, in the experimental part. The serving sizes were increased for the meatballs and potato mash in order to meet the requirements of sample weights prior to the external analysis.

TABLE 4-5. HOME RECIPES.

	Meatballs [55] 8 servings	**Potato mash** [56] 6 servings	**Pasta bolognese** [57] 4 servings
Source	ICA classical recipe	Arla® basic recipe	ICA basic recipe
Content	3 dl milk 10 tbsp breadcrumbs 1000 g minced meat 1 yellow onion (peeled, grated) 2 eggs 2 tsp salt 2 ml pepper 1 tsp sugar Butter or margarine	1.5 kg potato 3 dl milk 37.5 g butter 1.5 ml salt 3 ml white pepper	500 g minced beef 1 yellow onion (peeled, chopped) 2 garlic cloves (peeled, finely chopped) 2 carrots (peeled, grated) 2 tbsp cooking oil ½ dl tomato pure 500 g crushed tomatoes 2 dl chicken stock 2 tbsp Chinese soy Salt and black pepper 4 servings of spaghetti Additional spices

4.3.3 Instructions in Recipe

The cooking instructions from the chosen home recipes can be found in Table A-14 in Appendix, but with minor modifications in order to make the recipes more time-efficient and manageable. The unspecified descriptive words, times and temperatures in the instructions were open for interpretation, meaning that, the test subjects were allowed to interpret these instructions as they liked. Additionally, the test subjects were also allowed to add more of the given ingredients if that was needed for the final resulting dish. Supplementary spices were provided in the pasta bolognese recipe in order to increase the possibility to create an individual flavor profile. These spices were thyme, oregano, bay leaf, white pepper, chili pepper, and rosemary, which were a collection of all the spices from the 10 recipes.

4.4 Industrial Recipes

The industrial recipes originated from Orkla Foods Sweden AB, and this was how the dishes are produced in the factory. These recipes were assigned to treatment 1 and were slightly modified in order to be understandable and easy to follow for the test subjects. The potato mash was not investigated for treatment 1, as it was too difficult to replace the instructions in the industrial recipe with representable ones in a home kitchen.

4.4.1 Contents in Recipe

The contents in Table 4-6 below represent one cooking session, i.e., one replicate, in the experimental part. The amounts of each cooked dish were based on the amount of sample needed for nutritional analysis. The potato mash recipe was not cooked during the practical execution.

[redacted]

4.4.2 Instructions in Recipe

The cooking instructions from the industrial recipes can be found in Table A-15 in Appendix. The specified times and temperatures originating from the large-scale equipment were slightly adapted in order to fit the home-scale equipment. On the contrary to the home recipes, the test subjects were not allowed to add more of the given ingredients if that was needed for the final resulting dish. They were supposed to follow the content for each recipe strictly.

5 Execution

5.1 Practical execution

The practical execution took place in Orkla Foods' test kitchen in their factory in Eslöv. In the power analysis in section 4.2.2, it was concluded to have four replicates, meaning that this practical execution included four test subjects performing the home-cooking. Each test subject performed treatment 1 and treatment 2 for all three ready meal products, except the potato mash where treatment 1 was excluded, as motivated in section 4.4. This resulted in five home-cooked meals each performed in the test kitchen, which were based on the home and industrial recipes presented in Table 4-5 and Table 4-6.

5.1.1 Selection of Test Subjects

The selection of the four test subjects was based on a variety in gender and on self-evaluation of cooking ability and estimation of PAL, where the different PAL categories can be seen in Table A-6 in Appendix. BMR was calculated using the information in Table A-7 in Appendix. Relevant information concerning the chosen test subjects is summarized in Table 5-1 below.

TABLE 5-1. INFORMATION ABOUT TEST SUBJECTS.

No.	Cooking ability	Gender	Age (years)	Weight (kg)	PAL	BMR (MJ/day)	RDI (kJ/day)
1	Medium	Female	24	50	1.845*	5.136	9476
2	High	Male	26	70	1.845*	7.306	13480
3	Medium low	Male	23	81	1.845*	7.999	14758
4	Medium high	Male	24	73	1.845*	7.495	13828

*Active/moderately active lifestyle.
PAL = physical activity level.
BMR = basal metabolic rate.
RDI = recommended daily intake of energy. RDI = PAL*BMR.

5.2 Analysis of Results

The following section describes how the outcome of the practical execution is evaluated in order to turn into the obtained results and how these are analyzed.

5.2.1 Analysis Scheme

The experimental work resulted in a total of 26 samples, as presented below in Table 5-2. These samples generated nutritional values for the chosen nutrients in Table 3-1, which originated from the external nutrient content analysis performed by Eurofins. In addition, these samples were analyzed regarding the energy content. This was done by using a bomb calorimeter at the Department of Food Engineering, Technology and Nutrition at LTH.

TABLE 5-2. NUMBER OF SAMPLES TO SEND FOR ANALYSIS.

Ready meal product	Number of samples			
	Control	Treatment 1	Treatment 2	Total
Meatballs	2	4	4	10
Potato mash	2	-	4	6
Pasta bolognese	2	4	4	10
			Total number of samples	**26**

5.2.2 Hypothesis Testing

The hypothesis testing for the resulting nutrient content levels was done using multiple-way analysis of variance (ANOVA) for all treatments which generated p-values for the possible significant effects. This was followed by a multiple comparison test in MatLab (*multcompare*), in order to determine where the possible significant differences originated from. The test displayed the estimates from the ANOVA with comparison intervals around each treatment's mean value. The type of critical value used in the multiple comparison test is Tukey-Kramer, which was the Tukey's honest significant difference criterion. It also showed if the significant difference was due to a higher or lower nutritional content between the treatments in question. The used significance level α is 5%, and p-values were generated for each nutrient for each ready meal product. [58]

Figure 5-1 below shows an example of three generated comparison intervals for the protein content in meatballs, representing one treatment each. This three-way ANOVA generated a p-value of 2.31E-05. To interpret the intervals; treatment 2 (T2) had significantly higher protein content as the blue interval did not overlap with any of the red intervals. Treatment 1 (T1) and the control (C) were not significantly different from each other as the intervals overlapped. This interpretation was done for each nutrient level in each ready meal product, generating the results in Table 6-1, Table 6-4 and Table 6-6.

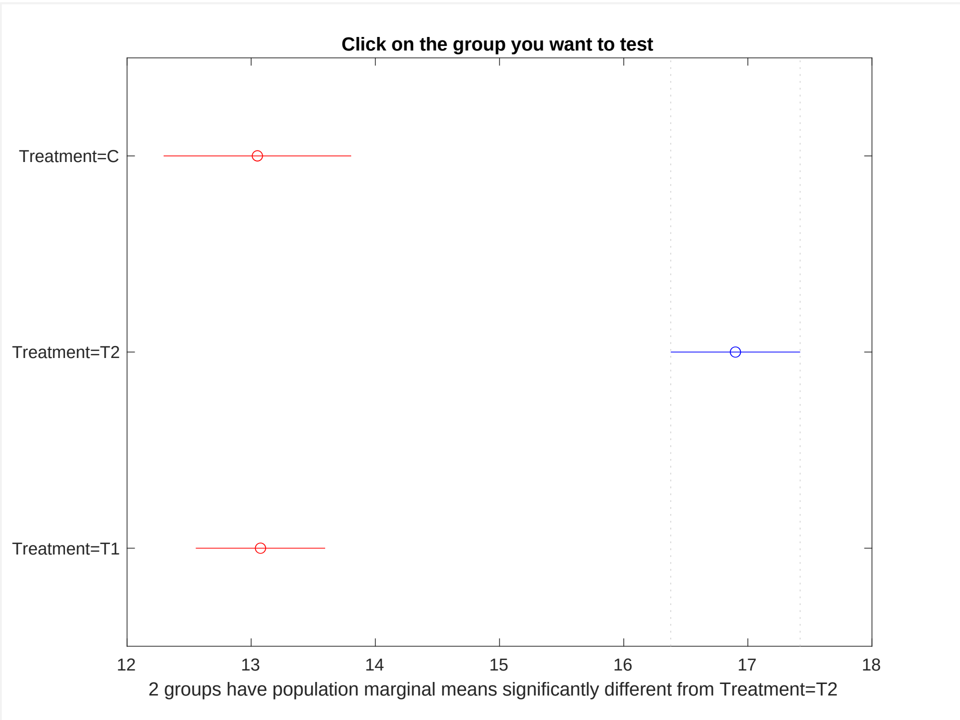

FIGURE 5-1. EXAMPLE OF COMPARISON INTERVALS FROM *MULTCOMPARE* IN MATLAB.

5.2.3 Sensitivity Analysis

Some nutrient contents were undetectable as the levels ended up under the limit of quantification (LOQ), which was specified as the smallest concentration that can be reliably measured by an analytical measuring method. For this, sensitivity analyses were performed in order to decide if the nutrient level should be set to its LOQ, or equal to zero. If the same conclusion could be drawn from both settings, i.e., identifying significant differences or not, it did not affect the final conclusion if the values were set to LOQ or to zero. Since the LOQ was close to zero, it was decided to set the values to zero if the same thing was concluded.

5.2.4 Complete Meals Analysis

In order to visualize complete meals with side dishes to further extend this study, the recommended side dishes from the recipes in Table A-14 were used. These were lingonberry jam and pickles with the meatballs and potato mash in combination, and parmesan cheese with the pasta bolognese. The test subjects were allowed to plate an optional amount of each side dish for the two complete meals during the practical execution. The first complete meal was meatballs with potato mash and lingonberry jam and pickles, and the second one was pasta bolognese with parmesan cheese. The nutritional values for the side dishes were theoretically calculated based on the test subjects' added weight and the nutrient values from SFA and the LanguaL™ database presented in section 2.1.1.4. The corresponding nutritional values for each food item per complete meal are summarized for each test subject.

For each complete meal, the analysis resulted in four complete home meals with treatment 2, since there were four test subjects, and two complete control meals which refer to the industrial ready meal product. The average weight of the lingonberry jam and pickles from treatment 2 was used for the complete control meal 1. The second complete control meal did not include parmesan cheese due to that already contained mozzarella. The reason why treatment 1 was not investigated was due to that the focus of the analysis was to compare the nutrient density in homemade meals and industrially made meals. In addition to this, the aim was also to investigate the test subjects' RDI in relation to their intakes of energy, salt and saturated fat for homemade and industrial made meals. Those three parameters were chosen because they were the most discussed and controversial nutrients regarding processed food.

6 Results

Complementary data, such as the raw data and NRF values can be found in Appendix A.4. In order to clarify, treatment 2 is the "homemade dish with home recipe", abbreviated as T2, treatment 1 is the "homemade dish with industrial recipe", abbreviated as T1, and the control is the "control product with industrial recipe", abbreviated as C.

6.1 Meatballs

6.1.1 Hypothesis Testing on Nutritional Contents

Table 6-1 below shows the results from the hypothesis testing where the control (C) and the two treatments (T1 and T2) are compared for all nutrient contents, with the p-values and the resulting nutrient content intervals showing the significant differences. The hypothesis testing is performed for all three reference units presented in section 2.6.2.

The vitamin A content was undetectable as the levels ended up under the LOQ. When performing the sensitivity analysis, it was concluded to set the values to zero. Therefore, the hypothesis testing is not possible to perform and set to *NaN*. The same is valid for vitamin D3, except one value that ended up above the LOQ. However, the rest of the values are set to zero.

TABLE 6-1. COMPARISON OF NUTRITIONAL CONTENTS FOR CONTROL (C), TREATMENT 1 (T1) AND TREATMENT 2 (T2) IN MEATBALLS.

Nutrient	Per 100 g		Per portion		Per 100 kcal	
	P-value	Sign.diff	P-value	Sign.diff	P-value	Sign.diff
Energy (kJ)	0.0932	-	0.156	-		
Protein (g)	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2
Saturated fat (g)	0.180	-	0.156	-	0.0207*	T1 < C
Salt (g)	0.0468*	T2 < T1	0.587	-	0.320	-
Calcium (g)	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2
Vitamin A (RE) (g)	*NaN*	-	*NaN*	-	*NaN*	-
Vitamin D3 (g)	0.528	-	0.528	-	0.528	-
Iron (g)	0.706	-	0.0146*	T1 < T2, C < T2	0.183	-
Potassium (g)	0.0131*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	0.0115*	T1 < T2, C < T2
Magnesium (g)	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2
Added sugar (g)	0.0360*	T1 < T2	0.0286*	T1 < T2	0.0437*	T1 < T2, C < T2
Portion size (g)			0.0113*	T1 < T2, C < T2		
Unit size[a] (g)			< 0.01*	T1 < T2, C < T2		

a. The unit size represents one unit meatball, where several units make up one portion.
*Below α=0.05.

6.1.2 NRF Indices

Table 6-2 shows the mean values of the calculated NRF indices based on the three different reference units, with the p-value and the resulting content intervals showing the significant differences between the treatments.

TABLE 6-2. NRF INDICES OF CONTROL (C), TREATMENT 1 (T1) & TREATMENT 2 (T2) IN MEATBALLS.

Meatballs	**Mean NRF indices**		
	Per 100 g	**Per portion**	**Per 100 kcal**
Control	-11 (± 5)	-11 (± 5)	-4 (± 2)
Treatment 1	-7 (± 2)	-9 (± 3)	-2 (± 1)
Treatment 2	19 (± 6)	34 (± 20)	7 (± 2)
P-value	< 0.01*	< 0.01*	< 0.01*
Sign.diff.	T1 < T2, C < T2	T1 < T2, C < T2	T1 < T2, C < T2

*Below α=0.05.

6.1.3 Weight Loss from Frying

Table 6-3 below shows the mean values for the relative weight loss from the frying process in all treatments. The relative weight loss for the control is set to a standardized value of 18%, a commonly observed value declared by Orkla Foods. The relative weight loss for treatment 1 and 2 is based on the weight difference between the raw weight and the fried weight for one meatball.

TABLE 6-3. MEAN VALUES FOR WEIGHT LOSS IN MEATBALLS FROM FRYING.

Mean values	**Weight raw meatball (g)**	**Weight fried meatball (g)**	**Weight loss (g)**	**Relative weight loss**
Treatment 1	16 (± 0)	12 (± 1)	5 (± 1)	29%
Treatment 2	35 (± 10)	25 (± 7)	10 (± 4)	27%
Control				18%[a]
P-value (Sign.diff.)				0.0380* (C < T1)

a. Standardized water loss according to Orkla Foods Sweden AB.
*Below α=0.05.

6.2 Potato Mash

6.2.1 Hypothesis Testing on Nutritional Contents

Table 6-4 below shows the results from the hypothesis testing where the control (C) and treatment 2 (T2) are compared for all nutrient contents, with the p-values and the resulting significantly different content intervals. The hypothesis testing is performed for all three reference units presented in section 2.6.2.

One value for the fiber content was undetectable as it was lower than the LOQ. When performing the sensitivity analysis, it was concluded to set the value to zero. The levels for vitamin D3 and folate were also below LOQ, and the sensitivity analyses decided to set them to zero. Therefore, the hypothesis testing is not possible to perform and set to *NaN*. The same applies for added sugar since no sugar was added in either of the recipes.

TABLE 6-4. COMPARISON OF NUTRITIONAL CONTENTS FOR CONTROL (C) & TREATMENT 2 (T2) IN POTATO MASH.

Nutrient	Per 100 g		Per portion		Per 100 kcal	
	P-value	Sign.diff	P-value	Sign.diff	P-value	Sign.diff
Energy (kJ)	0.0972	-	0.449	-		
Protein (g)	0.320	-	0.804	-	0.328	-
Dietary fiber (g)	0.817	-	0.0707	-	0.966	-
Saturated fat (g)	0.0166*	C < T2	0.0234*	C < T2	< 0.01*	C < T2
Salt (g)	0.173	-	0.157	-	0.0505	-
Calcium (g)	0.0171*	C < T2	0.0241*	C < T2	0.0944	-
Vitamin C (g)	0.0163*	C < T2	0.0926	-	0.0170*	C < T2
Vitamin D3 (g)	*NaN*	-	*NaN*	-	*NaN*	-
Folate (g)	*NaN*	-	*NaN*	-	*NaN*	-
Potassium (g)	0.201	-	0.245	-	< 0.01*	T2 < C
Magnesium (g)	0.765	-	0.917	-	0.0122*	T2 < C
Added sugar (g)	*NaN*	-	*NaN*	-	*NaN*	-
Portion size (g)			0.848	-		

*Below α=0.05.

6.2.2 NRF Indices

Table 6-5 shows the mean values of the calculated NRF indices based on the three different reference units, with the p-values and the resulting content intervals showing the significant differences between the treatments.

TABLE 6-5. NRF INDICES OF CONTROL (C) & TREATMENT 2 (T2) IN POTATO MASH.

Potato mash	Mean NRF indices		
	Per 100 g	Per portion	Per 100 kcal
Control	10 (± 3)	20 (± 6)	13 (± 4)
Treatment 2	12 (± 2)	25 (± 8)	15 (± 3)
P-value	0.456	0.491	0.675
Sign.diff.	-	-	-

*Below α=0.05.

6.3 Pasta Bolognese

6.3.1 Hypothesis Testing on Nutritional Contents

Table 6-6 below shows the results from the hypothesis testing where the control (C) and the two treatments (T1 and T2) are compared for all nutrient contents, with the p-values and resulting significantly different content intervals. The hypothesis testing is performed for all three reference units presented in section 2.6.2

The levels for vitamin D3 and folate were undetectable as they were below the LOQ. When performing the sensitivity analysis, it was concluded to set the values to zero. Therefore, the hypothesis testing is not possible to perform and set to *NaN*.

TABLE 6-6. COMPARISON OF NUTRITIONAL CONTENTS OF CONTROL (C), TREATMENT 1 (T1) AND TREATMENT 2 (T2) IN PASTA BOLOGNESE.

Nutrient	Per 100 g		Per portion		Per 100 kcal	
	P-value	**Sign.diff**	**P-value**	**Sign.diff**	**P-value**	**Sign.diff**
Energy (kJ)	0.0600	-	0.0722	-		
Protein (g)	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2
Dietary fiber (g)	0.0203*	T1 < T2, C < T2	0.0398*	T1 < T2	0.143	-
Saturated fat (g)	< 0.01*	T2 < T1, T2 < C, C < T1	0.0227*	T2 < T1	< 0.01*	T2 < T1, T2 < C
Salt (g)	0.518	-	0.884	-	0.152	-
Calcium (g)	< 0.01*	T2 < T1, T2 < C	0.0129*	T2 < T1	< 0.01*	T2 < T1, T2 < C
Vitamin A (RE) (g)	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2
Vitamin D3 (g)	*NaN*	-	*NaN*	-	*NaN*	-
Iron (g)	< 0.01*	T1 < T2, C < T2	0.0250*	T1 < T2	0.0232*	T1 < T2
Potassium (g)	0.0122*	T1 < T2, C < T2	< 0.01*	T1 < T2, C < T2	0.380	-
Magnesium (g)	0.0144*	T1 < T2, C < T2	0.0457*	T1 < T2	0.0310*	T1 < T2
Folate (g)	*NaN*	-	*NaN*	-	*NaN*	-
Added sugar (g)	0.528	-	0.528	-	0.528	-
Portion size (g)			0.125	-		

*Below α=0.05.

6.3.2 NRF Indices

Table 6-7 shows the mean values of the calculated NRF indices based on the three different reference units, with the p-values and the resulting content intervals showing the significant differences between the treatments.

TABLE 6-7. NRF INDICES OF CONTROL (C), TREATMENT 1 (T1) & TREATMENT 2 (T2) IN PASTA BOLOGNESE.

Pasta bolognese	Mean NRF indices		
	Per 100 g	**Per portion**	**Per 100 kcal**
Control	15 (± 2)	57 (± 8)	11 (± 2)
Treatment 1	16 (± 0)	62 (± 5)	11 (± 1)
Treatment 2	32 (± 4)	150 (± 24)	21 (± 3)
P-value	< 0.01*	< 0.01*	< 0.01*
Sign. diff.	T1 < T2, C < T2	T1 < T2, C < T2	T1 < T2, C < T2

*Below α=0.05.

6.4 Complete Meals Analysis

6.4.1 Meal 1: Meatballs and Potato Mash with Lingonberry Jam and Pickles

Table 6-8 shows the average portion size and NRF index for the four test subjects' and the two controls for the first complete meal.

TABLE 6-8. AVERAGE PORTION SIZE AND NRF INDEX FOR COMPLETE MEAL 1.

Complete Meal 1	Portion size (g)	NRF Index
Test subjects	440 (± 95)	49 (± 14)
Controls	370*	-1 (± 1)

*No standard deviation due to set weight from packaging and the test subjects' average weights of sides dishes.

Table 6-9 shows the percentages of the contents of energy, salt and saturated fat based on each test subjects' RDI value, which can be found in Table 5-1. These percentages are given for both the complete homemade meals and the complete control meals.

TABLE 6-9. PERCENTAGES OF RDI FOR COMPLETE MEAL 1.

Test subject	Complete Homemade Meal 1			Complete Control Meal 1		
	Energy /RDI	Salt /RDI	Saturated fat/RDI	Energy /RDI	Salt /RDI	Saturated fat/RDI
1	23%	38%	37%	22%	70%	34%
2	20%	76%	34%	16%	70%	24%
3	19%	77%	37%	14%	70%	22%
4	28%	75%	51%	15%	70%	23%
Mean	22%	66%	39%	17%	70%	25%
Std	4%	19%	8%	4%	0%	5%

Table 6-10 shows the statistical analysis for the complete meal, where the NRF index is significantly higher for the complete homemade meal (T2) than for the complete control meal (C). A significant difference can be found in the saturated fat content, where the complete homemade meal has a significantly higher amount of RDI. There is no significant difference regarding the portion size or the content in energy and salt of RDI.

TABLE 6-10. STATISTICAL ANALYSIS USING TWO-WAY ANOVA OF CONTROL (C) AND TREATMENT 2 (T2) FOR COMPLETE MEAL 1.

Complete Meal 1	NRF Index	Portion size	Energy/RDI	Salt/RDI	Saturated fat/RDI
P-value	< 0.01*	0.414	0.0904	0.712	0.0247*
Sign. diff.	T2 > C	-	-	-	T2 > C

*Below α=0.05.

6.4.2 Meal 2: Pasta Bolognese with Parmesan Cheese

The average portion sizes and the average calculated NRF indices for the second complete meal, for the four test subjects' homemade meals and the two controls are shown in Table 6-11.

TABLE 6-11. PORTION SIZE AND NRF INDEX FOR COMPLETE MEAL 2.

Complete Meal 2	Portion size (g)	NRF Index
Test subjects	470 (± 70)	170 (± 21)
Controls	380*	57 (± 8)

*No standard deviation due to set weight from packaging.

Table 6-12 shows the percentages of energy, salt and saturated fat content based on each test subjects' RDI values.

TABLE 6-12. PERCENTAGES OF RDI FOR COMPLETE MEAL 2.

Test subject	Complete Homemade Meal 2			Complete Control Meal 2		
	Energy /RDI	Salt /RDI	Saturated fat/RDI	Energy /RDI	Salt /RDI	Saturated fat/RDI
1	40%	109%	33%	22%	66%	22%
2	23%	93%	21%	16%	66%	16%
3	23%	74%	17%	14%	66%	14%
4	17%	40%	17%	15%	66%	15%
Mean	25%	79%	22%	17%	66%	17%
Std	10%	30%	8%	4%	0%	4%

Table 6-13 shows the statistical analysis for the complete meal, where the NRF score is significantly higher for the complete homemade meal (T2) compared to the complete control meal (C). There is no significant difference regarding the portion size or the content in energy, salt and saturated fat of RDI.

TABLE 6-13. STATISTICAL ANALYSIS USING TWO-WAY ANOVA OF CONTROL (C) AND TREATMENT 2 (T2) FOR COMPLETE MEAL 2.

Complete Meal 2	NRF Index	Portion size	Energy/RDI	Salt/RDI	Saturated fat/RDI
P-value	< 0.01*	0.157	0.159	0.433	0.263
Sign. diff.	T2 > C	-	-	-	-

*Below α=0.05.

7 Discussion

In order to clarify, treatment 2 (T2) will be referred to as the "homemade dish with home recipe", treatment 1 (T1) as the "homemade dish with industrial recipe", and the control (C) as the "control product with industrial recipe".

7.1 Meatballs

7.1.1 Nutritional Contents

The results in Table 6-1 show that the portion size is significantly larger for the homemade dish with home recipe (T2), compared to the other two with industrial recipe (C and T1). It also shows that the test subjects made significantly larger meatballs when they were allowed to decide the unit size in the home recipe (T2), compared to the standardized weight of approximately 14 grams per unit in the industrial recipe (C and T1). The unit size is based on the raw weight. When the test subjects were plating their individual portion sizes during the practical execution, it was observed that they aimed for the same number of meatballs, despite the apparent weight difference. This is interesting in a way as it indicates that consumers might have an unconscious predefined number of units to consume, in this case, number of meatballs. If so, it is favorable if the unit size is smaller in terms of avoiding overconsumption and excess energy intake. The aim of limiting the energy density in the diet is supported by the dietary guidelines stated by NNR 2012, in order to avoid diverse health effects related to the diet, presented in section 2.5. However, since the energy content per portion is not significantly different between the treatments, there is no dilemma to face in this case.

Another interesting observation related to the increased portion size for the homemade dish with home recipe (T2) is the salt content. There is a significant higher salt content per 100 g for the homemade dish with industrial recipe (T1) compared to the one with home recipe (T2). During the practical execution, the test subjects did not add significantly different amounts of salt. Thus, the significant difference in salt is probably due to that the different raw material has varying salt content. However, this salt difference is no longer significant when the salt content is based on the portion size instead. This is since the amount of salt increases in proportion to the portion size for the homemade dish with home recipe (T2) is increasing more, in relation to the other two portions. In other words, the increase in portion size for T2 cancels the observed significant difference in salt content per 100 g.

No significant difference in salt is found between the homemade dish with industrial recipe (T1) and the control product (C). Since these treatments have the same industrial recipe, i.e., the same raw material in equal amounts, a hypothetically found difference could therefore be derived to the different scales of processing. However, as no difference is detected, the salt content has not been affected by the processing, which is supported by section 2.4.1.4.

The same cancellation effect as for salt is observed for iron, but the opposite for the reference units. The iron content is significantly higher for the homemade dish with home recipe (T2) per portion compared to the other two with industrial recipe (C and T1), but no significant difference is detected per 100 g. This is also an outcome of the increased portion size for T2.

Regarding other nutrient levels for all three reference units, significant differences are observed between the homemade dish with home recipe (T2) and the two others with industrial recipe (C and T1) concerning the contents of protein, calcium, potassium and magnesium. In all cases, the homemade dish with home recipe (T2), has significantly higher contents. Since the comparisons between T1 and T2 are significantly different, it is probably due to the addition of different raw materials and different recipes. This is because that is what separates T1 from T2, since they use the same home equipment for the processing, explained in section 4.1.2.

However, the meat provided by Orkla Foods, blended at the ratio of 50/50, contained 17% protein for beef and 16% for pork, and the minced meat (blended 50/50) bought at the grocery store contained 19% protein in total. Furthermore, the industrial recipe contained significantly less meat (55%) compared to the home recipe (60%), calculated in raw weight. Therefore, this might be what causes the significantly higher protein content in the homemade dish with home recipe (T2), despite the similar protein content in the raw meat. The addition of other raw materials such as milk and egg will also influence the total protein content. Fundamentally, if the recipe contains more raw materials with higher protein content, the final protein content will be higher too.

As there is no significant difference between T1 and C, in nutrient levels, which differ in the production scale and use of equipment, none of the differences in nutrient levels can be derived as a consequence of the industrial processing. The absence of degradation of minerals and denaturation of protein due to processing is supported by section 2.4.1.4 and 2.4.1.2 respectively, where minerals are not that affected by heat, and protein denaturation requires a much longer cooking time, even though the cooking temperature is high.

Another theory for the causality concerning the nutrient levels could be that the two frying steps differ a lot between T2, whereas the meatballs are fried in a pan in the home recipe, and the C and T1, whereas they are deep-fried in oil in the industrial recipe. During the practical execution it was observed that the deep-fried meatballs maintained the weight and were perceived as moist and juicy when tasting. Consequently, this might be due to a difference in moisture in the two different meatballs, which might affect the actual nutrient concentration. This can probably be caused by both the absorption of oil when deep-frying and by the leakage of liquid from the meatballs. Additionally, this can also be affected by the water-holding capacity of the food product.

As seen in Table 6-3, the relative weight loss is not significant between the homemade dish with home recipe (T2) and the other two with industrial recipe (C and T1), but instead there is a significantly lower weight loss in C compared to T1. This could mean that the control has kept more moisture in the food matrix during the frying process, despite the use of the same deep-frying method. Therefore, it might be concluded that the change in weight loss is due to the use of different equipment, whereas the large-scale one used for the control has managed to maintain the weight in the final product, compared to the home-scale equipment for T1. However, it cannot be concluded whether the weight loss originates from a loss of water or from other compounds. From the amplitude of weight loss, it is not possible to draw any conclusions regarding the moisture content of the meatballs and this parameter was not included in the experimental design. Therefore, the theory of a higher concentration of nutrients in T2 cannot be rejected or proved correctly.

Additionally, the amount of added sugar is significantly higher for homemade dish with home recipe (T2), which is due to that the industrial recipe (C and T1) do not have sugar as an ingredient.

Concerning the saturated fat content in the meatballs, the only significant difference is found per 100 kcal where the control product (C) has significantly higher content than T1. As both treatments have the same industrial method, i.e., contains the same raw materials and the same recipe, the causing factor might be the production scale and equipment. In both treatments, after the frying step, the meatballs were cooked in the oven until they reached the same inner temperature, as declared in the industrial recipe in Table A-15 in Appendix. For T1, an ordinary oven found in a home kitchen was used, while the control product (C) was cooked using a steam oven in the industry, which makes it possible to reach higher temperatures. Consequently, T1 required a longer cooking time in order to reach the same inner temperature. As stated in section 2.4.1.1, fats can melt out from the product while frying and cooking, which could be a possible explanation for the significantly lower content in T1.

Another explanation for the significant difference in saturated fat content could be the use of fat in the frying step. The test subjects were allowed to add an optional amount of rapeseed oil for frying, where the different absorptions of oil in the meatballs could be a possible cause for the significant difference. However, this is affected by the temperature, time and surface area of the meatball with the pan and oil and can differ a lot. Another cause could be the ingoing raw material. Despite the use of the same raw material, the raw material originated from different batches which can cause some variation in saturated fat content, which is supported by section 2.4.5.

7.1.2 Nutrient Density

The nutrient density, i.e., the NRF11.3 index, per portion for the homemade dish with home recipe (T2) is significantly higher than both the control and the homemade dish with industrial recipe (C and T1). As seen in Table 6-2, T2 has a higher average NRF score of 34 while the other have -11 and -9 respectively. The NRF indices for C and T1 are not significantly different. If the two parts constituting the index are considered, as seen in Table A-27 in Appendix, it can be noticed that the sum with the nutrients to encourage is higher for T2, while the sums with nutrients to limit are more similar. This is due to a higher protein and overall mineral content in the homemade dish with home recipe (T2). Therefore, the difference in protein and mineral content might be due to different contents in the actual raw meat, which is supported by section 2.4.5, but also by the recipe.

The NRF index per 100 kcal is also significantly higher for the homemade dish with home recipe (T2), with the average score of 7 compared to -4 (C) and -2 (T1). C and T1 are not significantly different. The index of T2 has decreased and the indices of C and T1 have increased. The reason for the change in different directions might be due to that T2 is not as energy dense as the other, which creates different scaling factors. However, the difference in energy content is not significant, but it can still be a valid reason. The NRF index per 100 g is not discussed because of what is stated from previous studies in section 2.6.2.

To summarize, the NRF index per portion and per 100 kcal for the homemade dish with home recipe (T2) receives a significantly higher score than the two others with industrial recipe (C and T1), which receive scores not significantly different. The difference is probably due to the content of protein and minerals in the actual raw material and amounts in the recipe.

7.1.3 Summary

To summarize section 7.1.1 and 7.1.2 above, the results point in the direction that the industrial processing, i.e., the production scale and equipment, does not affect the nutritional content, but rather the different additions of raw material and different recipes. This is due to that no significant difference was found between the homemade dish with industrial recipe (T1) and the control product with industrial recipe (C) for all reference units, except saturated fat per 100 kcal. This was valid for both the nutritional values and the NRF indices. Referring to section 4.1.2, a difference between C and T1 would be due to the production scale and equipment. Therefore, the difference in nutrient levels cannot be caused by the industrial processing.

7.2 Potato Mash

7.2.1 Nutritional Contents

As seen in Table 6-4, most of the comparisons between the nutrient values have not generated significantly different results. The question arises whether this is due to an actual similarity between the homemade dish and the control product, or if the test subjects are too few in order to detect the tiny differences between the nutritional contents. However, as the ANOVA has been able to detect significant differences of most of the nutrients in the meat-containing dishes, the number of test subjects is sufficient. Therefore, it can be concluded that the homemade (T2) and the industrial (C) potato mash are somewhat similar to each other, despite the considerable difference in processing scale, raw material and recipe.

The results in Table 6-4 show that there is no significant difference in portion size between the homemade dish with home recipe (T2) and the control (C). This means that the test subjects plated portion sizes similar to the recommended amount on the packaging. Additionally, there is no significant difference in energy content per 100 g or per portion.

For all three reference units, a significant difference is observed in the saturated fat content. The homemade dish (T2) has a significantly higher content compared to the control with industrial recipe (C), which might be due to the optional addition of butter. The test subjects were allowed to add more of each ingredient in order to reach a pleasant flavor. During the practical execution, it was observed that all the four test subjects added more butter than the recipe declared. One of the test subjects even added 200% of the recommended amount. However, it is difficult to derive the difference in saturated fat content to neither the raw material content and the recipe, nor the production scale and equipment used, since both these factors are different in T2 and C as explained in section 4.1.2. Nevertheless, it is probably due to the optional addition of butter.

Concerning the calcium content, it is significantly higher for the homemade dish with home recipe (T2) per 100 g and per portion, compared to the control with industrial recipe (C). As above, it is difficult to derive this difference to neither the raw material and the recipe, nor the production scale and equipment used. However, the whole milk powder in the industrial recipe contains 0.88% (g/100g) calcium while the fresh milk in the home recipe contains 0.12%. Nevertheless, when combining these percentages with the added amounts of powder and milk respectively during the practical execution, it results in a significantly higher calcium addition in the home recipe (0.14% and 0.34% of total weight (g/100g) respectively). Therefore, the reason for the significantly higher content in T2 is caused by the amount of the raw material, despite the higher calcium content in the whole milk powder.

Additionally, the contents of potassium and magnesium per 100 kcal are significantly higher in the control product with industrial recipe (C) compared to the homemade dish with home recipe (T2). This is likely due to the addition of different raw material and in different amount. Additionally, as mentioned in section 2.4.1.4, potassium is the mineral sensitive to leaching which can cause an actual significant difference. Therefore, since the potatoes are boiled in the home recipe (T2), there is a risk that minerals have leached out in the boiling water. Also, the retention factor for potassium in potato is 1 for oven baking, as seen in Table A-3 in Appendix. This means that the mineral is rather persistent for processing which indicates that the production scale and equipment would maintain this nutrient level.

Another interesting nutrient content is the vitamin C per 100 g and per 100 kcal, where a significantly higher content is observed in the homemade dish with home recipe (T2) compared to the control with industrial recipe (C). The first evident cause could be the different raw material content, as seen in Table 4-5 and Table 4-6. However, it can also be due to the different processing steps in the two treatments. The potato powder used in the industrial recipe is dried in several steps, which is different from the fresh potato used in the home recipe. Additionally, the potato powder has a much larger surface area compared to regular potatoes, meaning that the vitamin C is more exposed to oxygen and heat in the potato powder. Consequently, there is a higher risk of degradation during processing but also during storage. As stated in section 2.4.1.4, vitamin C is one of the most heat sensitive vitamins. Therefore, degradation in the drying process could be a possible cause for the significantly lower content in the control product. However, the retention factors for vitamin C in potato in Table A-3 in Appendix are rather high, which indicates a relatively small loss after all.

7.2.2 Nutrient Density

The nutrient density, i.e., the NRF11.3 index, per portion for the homemade dish with home recipe (T2) is not significantly different from the control with industrial recipe (C), as seen in Table 6-5. The mean values are 25 and 20 respectively. In this case, both the sums of nutrients to encourage and to limit are relatively higher for the homemade dish with home recipe (T2) compared to C, seen in Table A-28 in Appendix. This is dominated by the higher vitamin C content in the sum to encourage, and by the higher saturated fat content in the sum to limit.

The NRF index per 100 kcal follows the same pattern; the homemade dish with home recipe (T2) has an average score of 15 and is not significantly higher than the control (C) which has an average score of 13. The sums to encourage are rather similar, but the sum to limit is relatively higher for the control compared to T2, which seems to be due to a higher salt content, as seen in Table A-31 in Appendix. However, there is no significant difference between the salt content. The NRF index per 100 g is not discussed because of what is stated from previous studies in section 2.6.2.

In general, the NRF indices have similar patterns for scoring as there are no significant differences between the treatments. To summarize, the homemade dish with home recipe (T2) has a slightly higher, but not significantly higher, score compared to the control with industrial recipe (C), probably due to the higher vitamin C content in T2.

7.2.3 Summary

To summarize section 7.2.1 and 7.2.2 above, it is difficult to conclude anything about the impact of processing on the nutritional content since there is no homemade dish with industrial recipe (i.e., T1) to compare T2 and C with. On one hand, some results indicate that the industrial processing does not affect the contents of macronutrients and minerals, but rather the different additions of raw material and different recipes. On the other hand, the results seem to indicate that the industrial processing might reduce the vitamin C content while preserving the potassium content. Nevertheless, the differences in vitamin C and potassium content could also be due to different contents in the raw material, as well as the different additions of them. Furthermore, many nutrient comparisons are not significantly different, and the nutrient densities were not significantly different for any of the reference units. Therefore, the two versions of potato mash seem to be relatively similar despite the considerable difference in processing.

7.3 Pasta Bolognese

7.3.1 Nutritional Contents

The results in Table 6-6 show that there is no significant difference in portion size between the three dishes (C, T1 and T2). This means that the test subjects' portions (T1 and T2) correspond to the standardized portion size of the ready meal product (C). Additionally, there is no significant difference in energy content per 100 g and per portion for the treatments.

All three reference units have a significant difference in the protein content, where the homemade dish with home recipe (T2) contains a significantly higher amount compared to the other two (C and T1). Since there is a significantly higher protein content in the homemade dish with home recipe (T2) compared to the one with industrial recipe (T1), it might be due to the different additions of raw material in different amounts. This is reasonable since the home recipe contains 35% minced beef, while the industrial recipe contains 20% minced beef. This is based on the contents in Table 4-5 and Table 4-6, where the percentage is calculated based on the raw weight. However, there is no significant difference between the two treatments with industrial recipe (C and T1). Since the production scale and equipment is the factor separating these two, it can be concluded that the processing does not affect the outcome in protein content. This is also supported by section 2.4.1.2, where it is stated that protein denaturation happens at unit operations where the protein is extracted, which is not the case. By having this difference in meat content, it also influences the contents of iron, potassium and magnesium since animal sources are rich in these minerals, supported by section 2.4.5, where these are significantly higher in the homemade dish with home recipe (T2).

Another significant difference is observed in the vitamin A content for all three reference units, where the homemade dish with home recipe (T2) has a significantly higher content compared to the other two with industrial recipe (C and T1). As for the protein content depending on the addition of meat, the same reason can probably be applied here. The home recipe (T2) contains carrots, crushed tomatoes and tomato puree, which are sources of vitamin A. On the contrary, the industrial recipe (C and T1) contains both spinach, crushed tomatoes, tomato puree and cherry tomatoes, which also are sources of vitamin A. However, carrot contains more vitamin A per 100 g which is probably the cause of the significantly higher content in T2. As stated in section 2.4.1.4, vitamin A is lost often due to oxidation at higher temperatures. However, since no significant difference is found between the dishes with industrial recipe (C and T1), the difference in vitamin A between C and T2 cannot be caused by the production scale, or the different equipment used in the processing. Therefore, the difference in vitamin A is probably caused by addition of the raw material, in this case carrots which have a higher vitamin A density. As stated in section 2.4.5, meat is also a source of vitamin A. However, it was the content of beta carotene that constituted the total vitamin A content as the vitamin A content originating from the animal sources was below LOQ, as seen in Table A-18 in Appendix.

Another impact that the addition of vegetables can have is on dietary fiber content, as both carrots, spinach and tomato contain a share of fibers. The dietary fiber content is significantly higher for the homemade dish with home recipe (T2) compared to the ones with industrial recipe (C and T1) per 100 g and compared to T1 per portion. This is due to that the home recipe (T2) contains 34% of vegetables rich in fiber, while the industrial recipe (C and T1) contains 20% of the mentioned vegetables, calculated in raw weight. Additionally, carrots are denser in fiber compared to spinach and tomato. The dietary fiber content is not significantly different between the two with industrial recipe (C and T1), meaning that the production scale and different equipment does not affect the outcome in fiber content, supported by section 2.4.1.3.

This higher content of dietary fiber in T2 can also be due to the larger addition of pasta to the complete dish. During the practical execution, it was observed that the test subjects added a higher percentage of pasta to the complete homemade dish, compared to the content in the control product. When calculating it by using the portion size values in Table A-19 in Appendix, the homemade dish (T2) consisted of approximately 47% pasta and 53% sauce, while the control (C) consisted of 39% pasta and 45% sauce. The reason for the lower percentages is that the industrial recipe (C and T1) includes an addition of 14% of vegetables (cherry tomatoes, bell pepper and spinach) and 2% mozzarella as topping on the final portion, while the home recipe does not. As mentioned above, there is no significant difference between the total portion sizes, and consequently, the amount of sauce is larger in T2. In combination with the higher meat content in the sauce for T2, this confirms the higher nutrient levels of protein and minerals.

It is also worth to mention that the fiber is fully combusted in the bomb calorimeter, causing a potentially higher energy content compared to the breakdown in the human body. However, as mentioned in section 1.4, the absorption of nutrients is not investigated. Nevertheless, this full combustion will not affect the results since all samples are treated the same way.

Another significant difference is detected for the saturated fat content, where the level is significantly higher in for the dishes with the industrial recipe (C and T1), compared to the homemade dish with home recipe (T2) per 100 g and per 100 kcal. Additionally, the saturated fat content in T1 is significantly higher than the content in T2 per portion. A possible explanation could be that mozzarella pearls are added in the industrial recipe, which might increase the saturated fat content since cheese and other milk products are sources of saturated fat. This could also be the reason for the significantly higher calcium content in the dishes with the industrial recipe (C and T1) per 100 g and per 100 kcal, and in T1 per portion, compared to the home recipe (T2).

Another potential explanation could be the saturated fat content in the ingoing raw material of meat. The beef provided by Orkla Foods contains 25% fat whereof 11% is saturated fat, where the beef provided by the grocery store contains 12% fat whereof 5.3% is saturated fat. As mentioned above, the home recipe contains 35% of minced beef while the industrial recipe contains 20% minced beef. By theoretical calculations, the saturated fat content is significantly higher for the meat in the industrial recipe. Therefore, despite the use of the same type of meat, the saturated content could be influenced by the raw material and the amount of it. This is supported by section 2.4.5, which states that the fat content within animals may differ.

Lastly, the higher pasta content would increase the carbohydrate content, which is not investigated in this study, and therefore also the energy content since carbohydrates contribute to energy. However, the energy contents for all reference units are not significantly different, but this might also be due to a cancellation effect from the saturated fat content. A significantly higher saturated fat content for the homemade dish with industrial recipe (T1) might cancel out the potential significantly higher energy content caused by a higher carbohydrate content in the homemade dish with home recipe (T2).

7.3.2 Nutrient Density

The nutrient density, i.e., the NRF11.3 index, per portion for the homemade dish with home recipe (T2) is significantly higher, compared to the control and the homemade dish with industrial recipe (C and T1) has, seen in Table 6-7. T2 has an average score of 150, while the other two have 57 and 62 respectively, which are not significantly different. As discussed, this is probably an effect of the higher content of meat, carrots and pasta in T2 since the contents of protein, fiber, vitamin A, iron, magnesium and potassium are the ones dominating the NRF index in the sum to encourage, seen in Table A-29 in Appendix. The sum to limit is hidden by this large sum, as it is higher for T2 too. This seems to be due to the higher salt content in the homemade dish with home recipe (T2). However, this difference is not significant between the treatments.

The NRF index per 100 kcal does not show as extreme values as the index per portion does. However, the homemade dish with home recipe (T2) still has a significantly higher NRF index, with an average score of 21 compared to the other two, both with a mean score of 11 (C and T1). The reason for the less extreme scores and why the difference is relatively smaller is probably due to the different scaling factors for the two reference units caused by the different energy densities. The NRF index per 100 g is not discussed due to what is stated previously in section 2.6.2.

To summarize, the homemade dish with home recipe (T2) receives significantly higher NRF index, while the two with industrial recipe get no significantly different scores (C and T1). This difference is probably due to the different additions of meat and vegetables in respective recipe.

7.3.3 Summary

To summarize section 7.3.1 and 7.3.2 above, regardless the reference unit, the results suggest that the industrial processing, i.e., the production scale and equipment, does not affect the nutritional content, but rather the different additions of raw material and different recipes. This seems to be due to the higher contents of meat, carrots and pasta in the home recipe (T2). However, despite the addition of 14% vegetables as topping in the industrial recipe (C and T1), the total content of vegetables is less in the industrial recipe. Therefore, it seems like the addition of meat dominates the contribution of minerals, which is clearly demonstrated with the significantly higher NRF indices for the homemade dish with home recipe (T2).

Additionally, the NRF indices for the treatments with industrial recipe were not significantly different (C and T1). Therefore, the addition of different raw materials in different amounts separates the treatments nutritionally.

7.4 Summary of Results

To connect the summaries from section 7.1.3, 7.2.3 and 7.3.3, regardless the reference unit, the overall conclusion is that the nutritional values are not affected by the industrial processing, i.e., the production scale and equipment. The nutrient levels are rather influenced by the different additions of raw material in varying amount and different recipes. Additionally, since the NRF11.3 indices for the treatments with the industrial recipe (C and T1) are not significantly different for the meat-containing ready meals, it can be concluded that the production scale and equipment do not affect the nutritional content, since this is what separates C from T1.

Furthermore, the two versions of potato mash (C and T2) seemed to be relatively similar despite the considerable difference in processing due to not that many significant differences.

In general, it seems like that the addition of meat is the largest contributor to both the content of protein and minerals, no matter the reference unit. This is due to the significantly higher NRF indices for the meat-containing homemade dishes with home recipe (T2). The vitamin A and fiber contents seemed to be affected by the addition of nutrient-dense vegetables. However, in almost all cases, the salt content was not significantly different between the treatments. Furthermore, the saturated fat content seemed to be affected by the fat content in the raw meat, as well as by the optional addition of butter and cheese. Additionally, the energy contents in all three ready meals were not significantly different between the treatments.

7.5 Comparison with Other Studies

The results and discussion above can be compared with the studies presented in section 2.3. In the comparisons between processed and homemade foods in section 2.3.2.1, the results of this study align with some of the findings in a cross-sectional study in the UK by Howard *et al.* in 2012 where ready meals were compared with main meals created by television chefs. Both studies concluded that the ready meals were significantly lower in protein, which was valid for the meatballs and pasta bolognese. Additionally, they concluded a significantly lower saturated fat content in the ready meals, which was valid only for the potato mash. However, the UK study concluded a significantly higher energy content in the ready meals, which was not concluded in this study since no significant differences were found.

Another study from Scotland by Naruseviciute *et al.* in 2015 aligned with this study in concluding no significant differences between the homemade and the ready meals regarding the energy content which is valid for all three investigated ready meal products in this study. It also concluded no significant differences in the protein and fiber content, which was valid for the potato mash in this study, and finally no significant differences in the salt content which was valid for the potato mash and pasta bolognese, when expressed per 100 g.

Finally, a study in the US by Wolfson & Bleich in 2015 concluded that home-cooking is associated with a healthier diet. However, depending on the definition of a "healthy diet", this conclusion might vary. Regarding this current study, the level of "healthiness" is measured in terms of the NRF index as stated in section 2.6. In that case, since the two meat-containing homemade dishes received significantly higher NRF scores regardless the reference unit compared to their corresponding ready meal product, the conclusion of this study aligns with the US study. However, it is worth to mention that the results of this study originate from experimental data where the results seem to depend on the inclusion of raw material rather than the processing. On the contrary, the US study is conducted by using theoretical collected data from NHANES, and thus, it cannot be assured what factor the results depend on.

In the studies about processed foods connected to health and nutrition in section 2.3.2.2, the results of this study align with some of the findings in a Canadian study by Moubarac *et al.* in 2017 where the association between consumption of ultra-processed food and the diet quality was investigated. The aligning conclusions were concerning the significantly lower nutrients levels in processed foods compared to non-ultra-processed. This applied to the protein, iron, magnesium and potassium contents valid for the meatballs and pasta bolognese, the fiber and vitamin A contents valid for the pasta bolognese, and the vitamin C content valid for the potato mash.

Another study performed in the US by Gupta *et al.* in 2019 presented results that said that ultra-processed foods had lower NRF9.3 indices, while unprocessed had higher scores. If homemade foods can be defined as "unprocessed", the conclusion of this study supports this for the meat-containing dishes since the homemade ones had significantly higher NRF11.3 indices. However, as in the US study, exceptions concerning the scoring existed, which was shown with the not significantly different NRF11.3 indices for the potato mash. Additionally, it concluded that ultra-processed foods seemed to have higher energy density and to be poorer in nutrients compared to unprocessed foods. The conclusion of this study did not align with the higher energy density since no significant differences were found between the different treatments. However, as the NRF indices were significantly lower for the two meat-containing ready meals, this could align with the US conclusion that these dishes were "poorer in nutrients" since the NRF score is an indication of the nutrient density of the food.

Throughout these comparisons, it should be kept in mind that what constitutes a ready meal and a homemade meal changes over time, and that it also differs between countries. Moreover, due the limited resources available in a project like this, only three dishes where investigated which makes the results in this study difficult to generalize. Consequently, it makes it difficult to determine to what degree the results comply with those in previous studies. This might also be an explanation for the rather large differences can be seen when comparing between previous studies. If the differences in nutrient density mainly depend on raw materials and recipes (rather than processing, as reported in this study), then the question arises to what extent ready meals and homemade meals differ in terms of energy density and nutrient density. This would be highly individual and depend on what meals, product line and cultural context that is being investigated. Additionally, the definitions and categorization of processed foods vary and are widely discussed.

However, it is still important to remember that none of the comparisons are done with studies performed in Sweden, which questions the actual comparability.

7.6 Complete Meal Analysis

As for the first complete meal; the meatballs and potato mash with lingonberry jam and pickles, the average NRF score for the test subjects' complete homemade meals is 49, and -1 for the complete control meals, which can be seen in Table 6-8. Table 6-10 shows that the NRF score of 49 is significantly higher, which could be due to the higher amount of nutrients to encourage, such as protein coming from a higher meat content, see Table A-33 and Table A-34. When it comes to the second complete meal; the pasta bolognese with parmesan cheese, shown in Table 6-11, the average NRF score for the test subject's complete homemade meals is 170 and 57 for the complete control meals. This NRF score is also significantly higher for the homemade meals, which can be seen in Table 6-13. This could be due to higher amount of nutrients to encourage, such as protein and fiber, see Table A-35 and Table A-36, which could be explained by a higher content of meat and carrots. In conclusion, the nutrient density for both complete meals are significantly higher in the homemade compared to the control.

The portion size has a large effect on the NRF index. However, as seen in Table 6-10 and Table 6-13, there is no significant difference in portion size between the complete homemade meal and the complete control meals, which is valid for both meatballs and potato mash with lingonberry jam and pickles, and the pasta bolognese with parmesan cheese.

The amount of energy of RDI, seen in Table 6-9 for the first complete meal (meatballs and potato mash with lingonberry jam and pickles) is similar for the complete homemade meals and the complete control meals, with average values of 22% respectively 17%. This is valid for the salt content as well, with average values of 66% for the homemade and 70% for the control. As seen in the same table, the salt content is 70% for all test subjects for the complete control meal. This is due to the recommended intake of salt is 6 grams regardless of gender or energy intake, but also due to the use of the average amount of salt for the control meals, hence no standard deviation. When it comes to the saturated fat content of RDI, the values are significantly different for the first complete meal, where the complete homemade meal has a higher content, see Table 6-10. Notable, the test subjects were allowed to taste the food during cooking of the homemade meal, hence could add more butter to their liking. However, the test subjects were also allowed to add more salt, but this did not show a significantly higher salt content in the homemade meals. Nevertheless, the control meal has not been influenced by any tasting, therefore not able to add more salt or butter. This could be an explanation why the complete homemade meal has significantly higher content of saturated fat.

As for the second complete meal; the pasta bolognese with parmesan cheese, the energy and salt content of RDI is also similar when comparing the complete homemade meals and the complete control meals. However, the saturated fat of RDI is not significantly different, but rather similar to each other. The average value for the homemade is 22% and for the control is 17%, as seen in Table 6-12. As discussed above in section 7.3.1, one possible explanation for the significantly higher saturated fat content in the control meal might be due to the addition of mozzarella. Since this difference is no longer found, it might be due to the addition of parmesan cheese which increases the saturated fat content in the complete homemade meal, and therefore, cancels out the previous difference. But the weight of parmesan cheese is not that high with an average of 10 grams, as seen in Table A-23 in Appendix, which can question this theory. However, the water content is lower for parmesan cheese compared to mozzarella, 28% and 66% respectively according to SFA, which means that a lower weight of parmesan is required in order to reach a similar saturated fat content.

Furthermore, the choice to not include parmesan cheese in the complete control meal 2 could be questioned. Thus, a sensitivity analysis with addition of parmesan cheese for the meal was performed. The addition of parmesan cheese results in a slightly increase in the NRF index and in the saturated fat provided by the meal. However, the same conclusion can be drawn as before, when parmesan cheese was not included.

Another observation is the test subjects' amount of salt of RDI, which can be seen in Table 6-9 and Table 6-12. For the meatballs and potato mash with lingonberry jam and pickles, the values for both homemade and control meals are around 70%. With one exception for the first test subject's complete homemade meal, which has a value of 38%. For the pasta bolognese with parmesan cheese, the controls have a value of 66%, while the homemade meals are more widespread, from 40% to 109%, with an average of 79%. All these values correspond to only one meal during a day since the percentages are high, which means that nearly all test subjects probably will exceed their RDI of salt from one meal, regardless of consuming complete meal number 1 or 2. This is of interest since the food industry is striving hard to reduce the salt content in their products and is often criticized for having high levels. However, this observation indicates that the homemade and ready meal are approximately at the same salt level.

As for the test subjects amounts of saturated fat and energy of RDI, all average values are around 20%, except for the saturated fat content for complete homemade meal 1. This indicates a well-balanced diet, corresponding to the NNR 2012. It is worth to mention that the energy values might not correspond to the actual ones, as the bomb calorimeter fully combusted all fiber in the samples. Nevertheless, this would probably not influence the reasoning considerably.

In conclusion, the values for energy and salt of RDI are not that different when comparing the complete homemade meal and control meals. This applies for both complete meals - the meatballs and potato mash with lingonberry jam and pickles, and the pasta bolognese with parmesan cheese. This is an indication that the test subjects' energy and salt content of RDI for homemade meals and industrial ready meals might be more alike than the general public believes. However, the saturated fat content of RDI varies depending on the type of complete meal.

7.7 Test Subjects

As stated in section 5.1.1, the selection of test subjects is based on a variety of gender and on individual evaluation of cooking ability. Since the test subjects evaluated their cooking ability differently, as seen in Table 5-1, it was expected that it would add variation to the homemade dishes (T1 and T2) as people's different cooking habits would probably affect the outcome. Naturally, the difference in cooking abilities would add in variation to the treatments regardless a widespread individual evaluation or a uniform such. Nevertheless, since the number of test subjects was small, a survey was used to characterize the test subjects. As seen in the result section, since the ANOVA was able to differentiate significant differences between the treatments, it means that the number of four test subjects was sufficient and that the difference in self-reported cooking abilities between the test subjects did not induce too much variation. Despite the skewed gender distribution (75% males and 25% females), it was decided that the spread in cooking abilities was prioritized. This decision was also made due to the time limitation and the possibility to source people that were able to spare a full weekday for the practical execution.

However, the decision of prioritizing cooking ability over gender, and thereof having a skewed gender distribution might also be limiting to the result interpretation of this study. By generalizing, test subject 1 is a female and will therefore, weigh less. As seen in Table 5-1, this results in a lower BMR and consequently, a lower RDI of energy. As the complete meal analysis in section 6.4 is based on the individual energy intakes, this might affect the analysis in a way. As seen for most of the percentages based on RDI in Table 6-9 and Table 6-12 the values for test subject 1, i.e., the female, are the highest. This influences the average values and the standard deviations for the ANOVA. However, the correlation between the highest percentages and the gender does not necessarily mean causality. Another potential cause for the higher percentages for the female could be that she plated larger portions, which contributes to higher contents of energy, salt and saturated fat. With that said, it is difficult to derive this observed pattern in percentages to a certain reason.

However, although both the complete meals, i.e., the homemade ones and the control meals, are affected by this gender distribution or different portion sizes, it might not affect the final result notably. Actually, when performing a sensitivity analysis where test subject 1 is excluded results in the same results as when including it. Nevertheless, it is important to keep this in mind and be carefully critical when drawing conclusions.

Another potential influence related to the time limitation is the lack of randomization when selecting the test subjects. This includes the skewed age distribution, since all four test subjects are in the age of 23 to 26 years. To make this study more representative for the general population, it is desired to have a wider age span, with test subjects corresponding to all different age groups. Additionally, as the test subjects evaluated their PAL the same, it is difficult to discuss their nutrient intakes in relation to their physical activity. An extension of the study would be to include test subjects that evaluate their PAL differently. It is believed that this would add in even more variation to the final results, which would result in the need of a larger number of test subjects in order to still be able to find significant differences in the results.

To conclude, it needs to be emphasized that the test subjects might not be representative of the entire Swedish population, which must be considered for conclusions.

7.8 Factors Influencing Variation within Treatments

There are several factors contributing to variations in this study. First, there is variation in between the homemade dishes, i.e., treatment 1 and 2. This is discussed in section 4.2, when the number of test subjects was deliberated and chosen to be four. However, it is not possible to eliminate all this variation as the test subjects introduce individual deviations during the entire practical execution. Therefore, it was decided to direct the test subjects by giving them the same recipes. The hypothesis of using the same kind of cooking methods, and by having the same types of raw material in the same amounts due to the variation within raw materials stated in section 2.4.5, is that it would narrow down the variation without not introducing too much bias. Fortunately, as seen in the results, the number of four replicates was sufficient to generate significant results.

Regarding the analysis of the results per 100 g, there is not only a naturally introduced variation from the test subjects, but also variation brought in from the method of the external nutritional analysis. The uncertainty created in the measurements ranges from ±10% to ±20% for the macronutrients, and from ±20% to ±25% for the micronutrients, reported by the external analysis company Eurofins. Concerning the undetected nutrient levels of vitamin D3 and vitamin A, the external firm does not consider the specified measurement uncertainties in comparison with the lowest threshold values.

Concerning the results per portion, there is additional variation introduced compared to the results per 100 g. This is due to the variation in portion sizes, since the test subjects were allowed to plate their individual portions. This might lead to other significant differences detected in the ANOVA, or fewer ones, since a cancellation effect might occur when the respective portion sizes differ between the treatments. This was observed for the salt content in meatballs per 100 g compared to per portion, as seen in Table 6-1.

The change in differences can also be caused by other variations such as systematic errors in measurements and calculations. If this prevents the discovery of significant results, it does not necessarily mean that the treatments are not similar, but more that those results are not possible to detect in the given situation. Additionally, the same reasoning is valid for the results per 100 kcal, as variation is introduced through the energy analysis performed with the bomb calorimeter. The analysis of energy content was performed in duplicates, in order to increase the precision of the measurement. The precision classification of the instrument is between 0.05 to 0.1% [59]. Additionally, the human factor might play a role.

In connection to section 7.4, it seems like the largest impact of variation on the results originates from the differences between the home recipe and the industrial recipe. This means having different raw materials in different amounts, and different nutritional contents in the same type of raw materials. Therefore, the significant differences detected in section 6 is mainly because of the use of different recipes and different raw materials, rather than the production scale or the equipment used. In relation to the classification systems in section 2.1.1, the different systems classify processed foods according to their extent, nature and purpose of processing. However, the results of this study indicate that the discrimination in nutritional content of homemade and processed food seems to be dependent mainly on the amount of various raw material rather than the level of processing. This is in accordance with the last study by Sadler *et al.* in 2021 in section 2.3.2.2, which concluded that the processing and the nutritional values do not have a linear relationship, and the study questions the use of "processing" as the best way of communicating nutritional differences in food.

The samples from the practical execution and prior to the external nutritional analysis were stored differently regarding the different treatments. The control products were stored according to the instruction on the package, and the homemade dishes with industrial recipe (T1) were stored in the same conditions. However, the homemade dishes with home recipe (T2), were stored according to 'what one should do at home', thus stored in the fridge. In addition to this, as stated in section 2.4.3 and 2.4.4, the nutritional content should not be altered in a significant way during the freezing process or during storage, especially when the number of days is relatively low. Thus, this should not influence the result of the nutritional content. Furthermore, the microwaving of the pasta bolognese dishes (C and T1) was done before sending them to the external analysis by using the microwave oven according to the instruction on the package. This method is the second most gentle method for not influencing the nutritional content as mentioned in section 2.4.2, hence should not alter the results either.

7.9 Future Perspectives

As mentioned in section 1.4 about delimitations, the sensory properties of the foods during the different treatments are not investigated. One way to expand this study is therefore to investigate how the nutritional content in processed and homemade food is affected by the consumers' sensory perceptions. Another way to extend this study could be to examine more ready meal products, or to examine the variation within the raw materials. Both suggestions were not included in this study due to different delimitations. However, as mentioned in section 2.4.5, there are inevitable nutritional changes in raw materials, hence it could be an interesting approach to investigate further, both within and between batches and brands.

A future perspective of this study is to update everything related to the NNR 2012 once the new edition of the NNR is available, which should be published in 2022 [60]. Notably, this means that the results and conclusion from this study may be affected. Moreover, as the NRF11.3 is used, another perspective could be to investigate other nutrient profiling indices, such as NRF22.3, which includes all vitamins and minerals, and to compare the different results and conclusions with each other. Furthermore, the NRF index can be used in combination with the food costs, which could be another future perspective. This combination could be used to identify foods that are more nutritious and affordable, consequently, this could help people to make more economical and nutrient rich food choices.

Home cooking is complex to define since the variation of people's cooking skills within consumer groups and between different groups is large. Therefore, one way to further investigate this master thesis' topic is to examine the variation within home cooking. In addition to this, the number of test subjects could be increased for the study to be more representative of the whole population, as mentioned in section 7.7.

Furthermore, the aspect of the environmental impact is another future perspective that could be investigated in the comparison of food that is homemade or manufactured in a large-scale industry. This is by for example performing a life cycle analysis for each dish and combine it with the nutrient density. In such an analysis, the aspect of the amount of meat in each dish could be a factor that can be taken into account in terms of climate impact, but also the energy and water use.

8 Conclusion

The largest impact of variation on the results and nutritional content in the processed and homemade variants originates from the differences in the home recipe and the industrial recipe. This is due to the addition of different raw materials in varying amounts, rather than the level of processing, i.e., the production scale and equipment used.

The conclusion of this study is that the nutrient density, i.e., the NRF11.3 index, per 100 kcal and per portion is significantly higher for the homemade dish with home recipe (T2) concerning the meat-containing dishes, mainly due to a higher meat content in the homemade meals. However, the dish without meat, i.e., the potato mash, did not have significantly different NRF indices. Also, the indices show no significant differences when comparing the control dish with industrial recipe (C) with the homemade dish with the same industrial recipe (T1), using the same raw materials. This is valid for the two investigated ready meal products having T1.

No significant difference was found in portion size for the potato mash and the pasta bolognese, but the portion size is significantly larger for the homemade meatballs with home recipe compared to the other two. However, this significant difference is eliminated when the meatballs are included in a complete dish with potato mash and side dishes.

No significant difference was found in energy content per 100 g (or per portion) for any of the three investigated meals. Also, when including these in complete meals, the recommended daily intake of energy seems to be more similar in the homemade dish and the industrial control than the general public believes. This also applied to the salt content.

No significant differences were found between the homemade dish with industrial recipe and the control, indicating that neither the production scale, nor the equipment, affect the nutritional content. In general, the significant differences in nutritional content are fewer concerning the potato mash compared to the two meat-containing dishes. Thus, the two versions of potato mash are more similar despite the considerable difference in processing.

The saturated fat content was significantly higher in the homemade potato mash, probably due to the optional addition of butter in the home recipe. On the contrary, the saturated fat content was significantly lower in the homemade pasta bolognese which was caused by a lower saturated fat content in the raw meat in the home recipe.

Significantly higher protein contents were found in the homemade meat-containing dishes, this is due to a higher meat content in the home recipes. Also, this probably caused the contents of potassium, magnesium and iron to be significantly higher.

The only difference concerning the salt content was the significantly lower amount in the homemade meatballs with home recipe per 100 g, which was eliminated per portion.

The vitamin A content was significantly higher in the homemade pasta bolognese due to the addition of carrots. The vitamin C was significantly lower in the industrial potato mash probably due to larger surface area of the potato powder, thus, more exposure to oxygen and heat.

Notably, the test subjects included in this study are not a representative random sample of the population and the conclusion is only valid for the three ready meal products. Finally, in order to control the nutrient density and nutritional content of a food product, this study concludes that the composition of the recipe and choice of raw material are the influencing factors rather than the extent of industrial processing.

References

[1] USDA, "Agricultural Marketing Service, USDA," *Authenticated U.S Governement Information, GPO*, 2010. https://www.govinfo.gov/content/pkg/CFR-2010-title7-vol3/pdf/CFR-2010-title7-vol3-sec65-220.pdf (accessed Feb. 11, 2021).

[2] FAO/WHO, *Codex Alimentarius: Pesticide Residues in Food*, Second., vol. 2. Codex Alimentarius Commission, 1993.

[3] LII, "21 U.S. Code § 321 -Definitions generally," *Legal Information Institute*. https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title21-section321&num=0&edition=prelim (accessed Feb. 17, 2021).

[4] C. A. Monteiro, G. Cannon, M. Lawrence, M. L. Costa Louzada, and P. Pereira Marchado, "Ultra-processed foods, diet quality, and health using the NOVA classification system," *Food and Agriculture Organisation of the United Nations*. FAO, Rome, Italy, pp. 1–44, 2019.

[5] H. A. Eicher-Miller, V. L. Fulgoni, and D. R. Keast, "Processed food contributions to energy and nutrient intake differ among US children by race/ethnicity," *Nutrients*, vol. 7, no. 12, pp. 10076–10088, 2015, doi: 10.3390/nu7125503.

[6] S. Davidou, A. Christodoulou, A. Fardet, and K. Frank, "The holistico-reductionist Siga classification according to the degree of food processing: An evaluation of ultra-processed foods in French supermarkets," *Food Funct.*, vol. 11, no. 3, pp. 2026–2039, 2020, doi: 10.1039/c9fo02271f.

[7] S. Davidou, A. Christodoulou, K. Frank, and A. Fardet, "A study of ultra-processing marker profiles in 22, 028 packaged ultra-processed foods using the Siga classification," *J. Food Compos. Anal.*, vol. 99, p. 103848, 2021, doi: 10.1016/j.jfca.2021.103848.

[8] Livsmedelsverket, "Livsmedelsdata," 2016. https://www.livsmedelsverket.se/om-oss/psidata/livsmedelsdatabasen (accessed May 11, 2021).

[9] Danish Food Informatics, "LanguaL™ - the International Framework for Food Description," 2015. https://www.langual.org/default.asp (accessed May 11, 2021).

[10] G. Ares *et al.*, "Consumers' conceptualization of ultra-processed foods," *Appetite*, vol. 1, no. 105, pp. 611–7, 2016, doi: 10.1016/j.appet.2016.06.028.

[11] EUFIC, "Understanding perceptions of processed food among UK consumers. A qualitative consumer study by EUFIC. EUFIC Forum n° 7," 2016. [Online]. Available: https://www.eufic.org/en/collaboration/article/eufic-forum-n-7-understanding-perceptions-of-processed-food-among-uk-consum.

[12] M. Mitchell, "The processed food industry: how does it meet the consumer perception challenge?," *Farrelly & Mitchell*, 2020. https://farrellymitchell.com/the-processed-food-industry-and-how-does-it-meet-the-consumer-perception-challenge/ (accessed Apr. 15, 2021).

[13] M.-E. Nilsson, "Äkta Vara - Den Hemlige Kocken." http://www.hemligekocken.se/kta-vara (accessed May 04, 2021).

[14] S. Könighofer, "Hur uppfattas och används begreppet processade livsmedel i samhället och i nutritionsstudier ?," Linnéuniversitetet, 2017.

[15] The British Dietetic Association, "Position statement - Processed Food," 2021. [Online]. Available: https://www.bda.uk.com/uploads/assets/06661eb4-b635-44a7-b3a1f753525c8f99/53f7356a-51eb-42c9-b1fbc6680230fbf3/Processed-Food-Position-Statement-FINAL-approved.pdf.

[16] E. Derbyshire, "Are all 'ultra-processed' foods nutritional demons? A commentary and nutritional profiling analysis.," *Trends Food Sci. Technol.*, vol. 94, pp. 98–104, 2019, doi:

10.1016/j.tifs.2019.08.023.

[17] S. Howard, J. Adams, and M. White, "Nutritional content of supermarket ready meals and recipes by television chefs in the United Kingdom: Cross sectional study," *BMJ*, vol. 345, no. 7888, pp. 1–10, 2012, doi: 10.1136/bmj.e7607.

[18] J. A. Wolfson and S. N. Bleich, "Is cooking at home associated with better diet quality or weight-loss intention?," *Public Health Nutr.*, vol. 18, no. 8, pp. 1387–406, 2015, doi: 10.1017/S1368980014001943.

[19] G. Naruseviciute, S. Whybrow, J. I. Macdiarmid, and G. McNeill, "Is 'home cooked' healthier and cheaper than ready meals?," *Proc. Nutr. Soc.*, vol. 74, no. OCE1, 2015, doi: 10.1017/s0029665115001056.

[20] C. Clifford Astbury, T. L. Penney, and J. Adams, "Comparison of individuals with low versus high consumption of home-prepared food in a group with universally high dietary quality: a cross-sectional analysis of the UK National Diet & Nutrition Survey (2008-2016)," *Int. J. Behav. Nutr. Phys. Act.*, vol. 16, no. 1, 2019, doi: 10.1186/s12966-019-0768-7.

[21] M. Heller, "The DASH diet," *2004*. https://dashdiet.org/ (accessed Mar. 07, 2021).

[22] F. Juul and E. Hemmingsson, "Trends in consumption of ultra-processed foods and obesity in Sweden between 1960 and 2010.," *Public Heal. Nutr.*, vol. 18, no. 17, pp. 3096–107, 2015, doi: 10.1017/S1368980015000506.

[23] L. Cousins, "National Health and Nutrition Examination Survey," *Encycl. Hum. Serv. Divers.*, 2014, doi: 10.4135/9781483346663.n401.

[24] C. M. Weaver *et al.*, "Processed foods: Contributions to nutrition," *Am. J. Clin. Nutr.*, vol. 99, no. 6, pp. 1525–1542, 2014, doi: 10.3945/ajcn.114.089284.

[25] J. M. Poti, M. A. Mendez, S. W. Ng, and B. M. Popkin, "Is the degree of food processing and convenience linked with the nutritional quality of foods purchased by US households?," *Am. J. Clin. Nutr.*, vol. 101, no. 6, pp. 1251–1262, 2015, doi: 10.3945/ajcn.114.100925.

[26] J. C. Moubarac, M. Batal, M. L. Louzada, E. Martinez Steele, and C. A. Monteiro, "Consumption of ultra-processed foods predicts diet quality in Canada," *Appetite*, vol. 108, pp. 512–520, 2017, doi: 10.1016/j.appet.2016.11.006.

[27] E. Martínez Steele, B. M. Popkin, B. Swinburn, and C. A. Monteiro, "The share of ultra-processed foods and the overall nutritional quality of diets in the US: Evidence from a nationally representative cross-sectional study," *Popul. Health Metr.*, vol. 15, no. 1, pp. 1–11, 2017, doi: 10.1186/s12963-017-0119-3.

[28] S. Gupta, T. Hawk, A. Aggarwal, and A. Drewnowski, "Characterizing ultra-processed foods by energy density, nutrient density, and cost," *Front. Nutr.*, vol. 6, pp. 1–9, 2019, doi: 10.3389/fnut.2019.00070.

[29] A. Drewnowski, S. Gupta, and N. Darmon, "An Overlap Between 'Ultraprocessed' Foods and the Preexisting Nutrient Rich Foods Index?," *Nutr. Today*, vol. 55, no. 2, pp. 75–81, 2020, doi: 10.1097/NT.0000000000000400.

[30] G. C. Andrade *et al.*, "Consumption of ultra-processed food and its association with sociodemographic characteristics and diet quality in a representative sample of French adults," *Nutrients*, vol. 13, no. 2, pp. 1–14, 2021, doi: 10.3390/nu13020682.

[31] C. R. Sadler, T. Grassby, K. Hart, M. Raats, M. Soković, and L. Timotijevic, "Processed food classification: Conceptualisation and challenges," *Trends Food Sci. Technol.*, vol. 112, pp. 149–162, 2021, doi: 10.1016/j.tifs.2021.02.059.

[32] H. Enroth and I. Mattisson, "Näringsförändringar i livsmedel vid tillagning," *Livsmedelsverket*, vol. 2, no. 21. 2017, [Online]. Available:

https://www.livsmedelsverket.se/globalassets/publikationsdatabas/rapporter/2017/2017-nr-21-del-2-naringsforandringar-vid-tillagning-och-forvaring-riskvarderingssrapport.pdf.

[33] L. Jonsson, I. Marklinder, M. Nydahl, and A. Nylander, "Livsmedelskvalitet," in *Livsmedelsvetenskap*, 2nd ed., Lund: Studentlitteratur, 2014, pp. 29–34.

[34] S. Damodaran, "Amino Acids, Peptides, and Proteins," in *Fennema's Food Chemistry*, 5th ed., S. Damodaran and K. L. Parkin, Eds. Boca Raton: CRC Press, 2017, pp. 330–346.

[35] Food Insight, "Fiber Fact Sheet," 2019. https://foodinsight.org/fiber-fact-sheet/ (accessed Apr. 07, 2021).

[36] HealthLinkBC, "Healthy Eating Guidelines For Reducing Dietary Fibre," *British Columbia*, 2010. https://www.healthlinkbc.ca/healthy-eating/reducing-dietary-fibre (accessed Apr. 07, 2021).

[37] E. Lešková, J. Kubíková, E. Kováčiková, M. Košická, J. Porubská, and K. Holčíková, "Vitamin losses: Retention during heat treatment and continual changes expressed by mathematical models," *J. Food Compos. Anal.*, vol. 19, no. 4, pp. 252–276, 2006, doi: 10.1016/j.jfca.2005.04.014.

[38] V. Öhrvik, M. H. Carlsen, A. Källman, and T. A. Martinsen, "Improving food composition data by standardizing calculation methods," *Improving food composition data by standardizing calculation methods*. 2015, doi: 10.6027/tn2015-568.

[39] D. D. Miller, "Minerals," in *Fennema's Food Chemistry*, 5th ed., S. Damodaran and K. L. Parkin, Eds. Boca Raton: CRC Press, 2017, pp. 657–666.

[40] Harvard Health Publishing, "Microwave cooking and nutrition," 2019. https://www.health.harvard.edu/staying-healthy/microwave-cooking-and-nutrition (accessed Mar. 02, 2021).

[41] R. P. Singh and D. R. Heldman, "Food Freezing," in *Introduction to Food Engineering*, 5th ed., Davis: Academic Press, 2014, pp. 521–563.

[42] M. Berry, J. Fletcher, P. McClure, and J. Wilikinson, "Effects of Freezing on Nutritional and Microbiological Properties of Foods," in *Frozen Food Science and Technology*, 1st ed., J. A. Evans, Ed. Oxford: Blackwell Publishing Ltd, 2008, pp. 26–50.

[43] M. S. Rahman and J. F. Velez-Ruiz, "Food Preservation by Freezing," in *Handbook of Food Preservation*, 2nd ed., M. S. Rahman, Ed. Boca Raton: CRC Press, 2007, pp. 636–656.

[44] M. A. Dandago, "Changes in Nutrients During Storage and Processing of Foods - a Review," *Techno Sci. African J.*, vol. 3, no. 1, pp. 24–27, 2009, [Online]. Available: https://www.researchgate.net/publication/294736406_Changes_in_nutrients_during_storage_and_processing_of_Foods_-_A_review.

[45] J. F. Gregory III, "Vitamins," in *Fennema's Food Chemistry*, 5th ed., S. Damodaran and K. L. Parkin, Eds. Boca Raton: CRC Press, 2017, pp. 553–559.

[46] R. S. Ahmad, A. Imran, and M. B. Hussain, "Nutritional Composition of Meat," *Meat Sci. Nutr.*, 2018, doi: 10.5772/intechopen.77045.

[47] L. Jonsson, I. Marklinder, M. Nydahl, and A. Nylander, "Grönsaker," in *Livsmedelsvetenskap*, 2nd ed., Lund: Studentlitteratur, 2015, pp. 107–109.

[48] Livsmedelsverket, "Näringsrekommendationer," 2020. https://www.livsmedelsverket.se/matvanor-halsa--miljo/kostrad/naringsrekommendationer (accessed Feb. 19, 2021).

[49] B. Sandstrom, N. Lyhne, J. I. Pedersen, A. Aro, I. Thorsdottir, and W. Becker, "Nordic nutrition: Recommendations 2012," *Scandinavian Journal of Nutrition/Naringsforskning*, vol. 40, no. 4. pp. 1–629, 2012, doi: 10.6027/Nord2014-002.

[50] P. Shetty *et al.*, "5. ENERGY REQUIREMENTS OF ADULTS," 2001. [Online]. Available: http://www.fao.org/3/y5686e/y5686e07.htm.

[51] A. Drewnowski, "The nutrient rich foods index helps to identify healthy, affordable foods," *Am. J. Clin. Nutr.*, vol. 91, no. 4, pp. 1095–1101, 2010, doi: 10.3945/ajcn.2010.28450D.

[52] M. Bianchi, A. Strid, A. Winkvist, A. K. Lindroos, U. Sonesson, and E. Hallström, "Systematic evaluation of nutrition indicators for use within food LCA studies," *Sustain.*, vol. 12, no. 21, p. 8992, 2020, doi: 10.3390/su12218992.

[53] A. Drewnowski, M. Maillot, and N. Darmon, "Should nutrient profiles be based on 100g, 100 kcal or serving size?," *Eur. J. Clin. Nutr.*, vol. 63, no. 7, pp. 898–904, 2009, doi: 10.1038/ejcn.2008.53.

[54] Food & Friends, "Matrapporten 2020," 2020. [Online]. Available: https://www.foodfriends.se/wp-content/uploads/2020/06/Matrapporten_2020_web.pdf.

[55] ICA, "Klassiska köttbullar." https://www.ica.se/recept/klassiska-kottbullar-712807/?referrer=#pfset=1 (accessed Feb. 16, 2021).

[56] Arla, "Grundrecept potatismos." https://www.arla.se/recept/grundrecept-potatismos/ (accessed Feb. 16, 2021).

[57] ICA, "Spaghetti och köttfärssås." https://www.ica.se/recept/spaghetti-och-kottfarssas-712805/ (accessed Feb. 22, 2021).

[58] MathWorks, "Multiple comparison test - MATLAB multcompare." https://www.mathworks.com/help//stats/multcompare.html (accessed May 02, 2021).

[59] P. I. Company, "6200 Isoperibol Calorimeter." https://www.parrinst.com/products/oxygen-bomb-calorimeters/6200-isoperibol-calorimeter/ (accessed May 09, 2021).

[60] Helsedirektoratet, "Nordic Nutrition Recommendations 2022." https://www.helsedirektoratet.no/english/nordic-nutrition-recommendations-2022 (accessed May 11, 2021).

[61] Felix, "Klassiska Köttbullar." https://www.felix.se/products/klassiska-kottbullar/ (accessed Feb. 15, 2021).

[62] Felix, "Klassiskt Potatismos 12 portioner." https://www.felix.se/products/klassiskt-potatismos-6-portioner/ (accessed Feb. 15, 2021).

[63] Felix, "Fettucine Bolognese." https://www.felix.se/products/fettucine-bolognese/ (accessed Feb. 23, 2021).

Appendix

A.1 Theoretical Background

A.1.1 Classification Systems

TABLE A-1. THE CLASSIFICATION OF NOVA.

Group*	Examples*
#1 Unprocessed or minimally processed foods	Fresh, dried, chilled frozen, squeezed fruit and root vegetables. Grains and legumes. Meat, fish, seafood in whole or in the form of steaks. Fresh or pasteurized milk or juice (with no added sugar, sweeteners or flavours.
#2 Processed culinary ingredients	Vegetable oils made from crushed seeds, nuts or fruits, or vegetables oils with antioxidants. Butter from milk. Sugar and molasses from beet and cane. Honey from combs. Salt from seawater. Include group 2 item with added vitamins or minerals, such as table salt including iodine.
#3 Processed foods	Seeds and nuts that is sugared or salted. Vegetables and legumes in brine which is canned or bottled. Meats and fish in form of dried, smoked, cured. Canned fish with/without preservatives. Freshly breads and cheeses that is unpackaged.
#4 Ultra-processed foods	Ready-to-consume products such as carbonated soft drinks, packaged snacks, chocolate, candies, ice cream, cookies, spreads, breakfast cereals, milk drinks, fruit yoghurts. Pre-prepared ready-to-heat products such as dishes like pies, pasta, pizza, fish nuggets or sticks, burgers, hot dogs, instant soups, noodles and desserts. Baby products such as infant formulas. Meal replacement shakes and powders.

* [4]

TABLE A-2. THE CLASSIFICATION OF SIGA.

Group*	Definition*	Degree of processing*	Substance assessed at risk*	Nutritional FSA thresholds*	Examples **
A0. Unprocessed foods	No processing, expect cutting and peeling	No MUP	No at-risk substances	Not considered	Fresh peas
A1. Minimally processed + A2 culinary ingredients	Physical and/or thermal treatment without purification or denaturation	No MUP	No at-risk substances	Not considered	Traditional tofu
B1. Nutritionally balanced	Adding culinary ingredients (A2) to a preparation	No MUP	No at-risk substances	Low	Canned peas with added salt below

processed foods					FSA threshold
B2. High salt, sugar and/or fat level processed food	Adding culinary ingredients (A2) to a preparation	No MUP	No at-risk substances	High	Soya sauce with added salt above FSA threshold
C01. Nutritionally balanced ultra-processed foods level 0	Ultra-processed foods with only one MUP1	Only one MUP1	No at-risk substances	Low	Peas with added starch (MUP1)
C02. High salt, sugar and/or fat level ultra-processed foods level 0	Ultra-processed foods with only one MUP1	Only one MUP1	No at-risk substances	High	Hummus with high level of added refined oil
C1. Ultra-processed foods level 1	Ultra-processed foods with multiple MUP1	Limitation of the number of MUP1. (Less than 5 MUP1)	No at-risk substances	Not considered	Pea-based meat substitutes with added pea protein and aromas
C2. Ultra-processed foods level 2	Ultra-processed foods which may present several MUP1 and/or MUP2 and/or substances evaluated at risk	More than 5 MUP1 and/or 1 MUP2 and/or 1 at-risk additive	Possible presence of substances evaluated at risk	Not considered	
C3. Ultra-processed foods level 3	Ultra-processed foods which may present several MUP1 and/or MUP2 and/or substances evaluated at risk	Presence of MUP1. Possible presence of MUP2.	Possible presence of substances evaluated at risk	Not considered	

* Modified from [7]
** [6]

A.1.2 Nutritional Change

TABLE A-3. RETENTION FACTORS FOR SOME DIFFERENT FOODS AND NUTRIENTS, VALUES ≤ 0.6 INDICATING A LOW RETENTION. *

	Vitamin C	**Folate**	**Vitamin D**	**Potassium**
		Vegetables and pulses		
Boiling	**0.55**	**0.6**	0.9	0.7
Frying	**0.6**	0.7	0.9	1
Oven baking	0.65	0.65	0.9	1
		Potato and root vegetables		
Boiling	0.75	1	N/A	0.9
Frying	0.8	0.75	N/A	1
Oven baking	0.7	0.7	N/A	1
		Cheese and dairy products		
Boiling	N/A	0.8	1	1
Frying	N/A	**0.5**	1	1
Oven baking	N/A	**0.5**	1	1
		Meat, meat products and offals		
Boiling	N/A	0.65	0.8	**0.6**
Frying	N/A	0.85	0.8	0.7
Oven baking	N/A	0.85	0.9	0.75
		Fat and oil		
Boiling	N/A	N/A	0.9	N/A
Frying	N/A	N/A	0.8	N/A
Oven baking	N/A	N/A	**0.45**	N/A

* [38]

A.1.3 Recommended Daily Intake

A.1.3.1 Macronutrients

TABLE A-4. RDI OF MACRONUTRIENTS.

Macronutrient	**RDI**	**Macronutrient**	**RDI**
Total fatty acids	25-40 E%	Carbohydrates	45-60 E%
Polyunsaturated fatty acids	5-10 E%	Dietary fiber	25-35 g
Monounsaturated fatty acids	10-20 E%	Added sugar	< 10 E%
Saturated fatty acids	< 10 E%	Protein	10-20 E%
Trans fatty acids	As low as possible		

A.1.3.2 Micronutrients

TABLE A-5. RDI OF MICRONUTRIENTS FOR ADULTS (AGE 18-30).

RDI	**Vitamins**			**Minerals**	
	Men	Women		Men	Women
Vitamin A (RE[a])	900	700	Calcium (mg)	800	800
Vitamin D (μg)	10	10	Phosphorus (mg)	600	600
Vitamin E (α-TE[b])	10	8	Potassium (g)	3.5	3.1
Thiamin (mg)	1.4	1.1	Magnesium (mg)	350	280
Riboflavin (mg)	1.6	1.3	Iron (mg)	9	15
Niacin (NE[c])	19	15	Zink (mg)	9	7
Vitamin B6 (mg)	1.5	1.2	Copper (mg)	0.9	0.9
Folate (μg)	300	400	Iodide (μg)	150	150
Vitamin B12 (μg)	2.0	2.0	Selenium (μg)	60	50
Vitamin C (mg)	75	75	Sodium as salt (g)[d]	2.4	2.4

a. 1 retinol equivalent (RE) = 1 μg retinol = 12 μg beta carotene.

b. 1 α-tocopherol equivalent (α-TE) =1 mg RRR-α-tocopherol.

c. 1 niacin equivalent (NE) = 1 mg niacin = 60 mg tryptophan.

d. A gradual reduction is desirable.

A.1.3.3 PAL and BMR

TABLE A-6. CLASSIFICATION OF LIFESTYLE RELATED TO PHYSICAL ACTIVITY.

Category	**PAL value**
Sedentary or light activity lifestyle	1.40-1.69
Active or moderately active lifestyle	1.70-1.99
Vigorous or vigorously active lifestyle	2.00-2.40

TABLE A-7. EQUATIONS FOR ESTIMATING BMR, WHERE 'M' IS MASS EXPRESSED IN KILOGRAMS.

Age	**BMR (MJ/day)**	
	Men	**Women**
18-30 years	0.063*m + 2.896	0.062*m + 2.036

A.2 Ready Meal Products

A.2.1 Product Information

TABLE A-8. NUTRITION VALUES PER 100 G FOR THE READY MEAL PRODUCTS.

	Nutrition values per 100 g		
	Meatballs [61]	Ready to eat potato mash [62]	Fettuccine Bolognese [63]
Energy (kJ)	994	270	516
Energy (kcal)	238	63	123
Protein (g)	13	1.5	5.3
Carbohydrates (g)	7.2	12	16
Whereof sugar types (g)	1.0	0.7	2.4
Fat (g)	17	0.8	3.8
Whereof saturated (g)	7.0	0.4	1.5
Salt (g)	1.7	0.6	1.1

TABLE A-9. PRODUCT INFORMATION FOR ONE PACKAGE CLASSICAL MEATBALLS.

	Meatballs [61]	
Portions	Weight	Storage
7	700 g	≤ -18°C in freezer
Preparation	In pan: Heat it with some oil. Fry the meatballs from frozen at medium/high heat for approximately 12 minutes. They should be in one layer. Stir often to avoid burning. In oven (200°C hot-air): Put the frozen meatballs in an oven-safe vessel and heat for approximately 20 minutes. Stir after 10 minutes. In microwave (800W): Put the frozen meatballs evenly distributed on a plate. Heat 1 portion (8 pcs) for approximately 3 minutes, without lid. The effect between microwaves may vary. The meatballs should be heated properly and are done when they are very hot inside.	
Ingredients	Beef and pork (68%), onion, egg, milk, breadcrumbs (with wheat flour), salt, black pepper extract and rapeseed oil.	

TABLE A-10. PRODUCT INFORMATION FOR ONE PACKAGE POTATO MASH.

	Potato Mash [62]	
Portions	Weight	Storage
6	220 g	Dry and room temperature. Cold storage after opening.
Preparation	If you wish for a richer mash, you can exchange some of the water for milk. Season with more spices and some butter/oil. In pot: Bring water to the boil, remove the pot from the heat and add the powder while whisking. Tea kettle (3 portions): Pour 5 dl boiling water in a bowl. Add 1 ½ dl powder while whisking. In microwave (750W, 2 portions): Add 1 dl powder in 3 dl water while whisking. Heat for approximately 3 minutes. Whisk again.	
Ingredients	Dried potato (89%), milk powder, salt, vegetable fat (palm, rapeseed), black pepper extract, butter aroma, stabilizers (E450, E471) and antioxidants (E223 sulfite, E300, E304).	

TABLE A-11. PRODUCT INFORMATION FOR ONE PACKAGE FETTUCCINE BOLOGNESE.

	Fettuccine Bolognese [63]	
Portions	Weight	Storage
1	380 g	≤ -18°C in freezer

Preparation	Cook in microwave at 750W from frozen: 1. Puncture some holes in the plastic wrap that covers the bowl. 2. Heat for approximately 5-6 minutes. 3. Stir. 4. Wait some minute before eating. The effect between microwaves may vary.
Ingredients	Pasta (39%) (water, durum wheat flour, whole egg powder, sunflower oil, salt, turmeric), water, beef (9%), cherry tomato, tomato puree, tomato, spinach, onion, grilled paprika (3%), mozzarella cheese (2%), beef broth (beef, water, salt, sugar, juice concentrate (carrot, onion)), rapeseed oil, starch, garlic, salt, sugar, spices (chili pepper, basil, cumin), caramelized sugar.

A.3 Experimental Planning

A.3.1 Variation Analysis

These recipes had most nutrient values closest to each median nutrient value, meaning that they had the highest percentage of median-comparable nutrients. This was measured both for all nutrients and for the NRF nutrients. The selection of the recipes also included having a high number of ratings. The recipe number refers to the 10 home recipes that were investigated.

TABLE A-12. NUMBER OF RATINGS AND % OF MEDIAN-COMPARABLE NUTRIENTS.

Recipe no.	Ratings	Percentage of all median-comparable nutrients	Percentage of NRF median-comparable nutrients
		Meatballs	
2	**221 pcs**	**81%**	**85%**
7	360 pcs	75%	77%
		Potato mash	
3	**241 pcs**	**96%**	**92%**
4	19 pcs	96%	92%
		Pasta Bolognese	
1	455 pcs	78%	77%
6	**256 pcs**	**86%**	**85%**

A.3.2 Home Recipes

TABLE A-13. BRANDS OF INGREDIENTS FOR HOME RECIPES BASED ON POPULARITY.

Ingredient	Brand	Volume per package
Bay leaf	Santa Maria	4 g
Black pepper	Santa Maria	30 g
Breadcrumbs	Wasa	400 g
Butter	Valio – regularly salted	500 g
Carrot	ICA Swedish	2 kg
Chicken stock (cube)	Knorr	12 pcs
Chili pepper	Santa Maria	34 g
Chinese soy	Pearl River Bridge	0.5 L
Crushed tomatoes	ICA	500 g
Egg	Kronägg	12 pcs
Garlic	ICA eco	200 g
Milk	ICA 1.5% fat. 0.12% calcium.	1.5 L
Minced beef	ICA Swedish, 12% fat whereof 5.3% saturated fat. 19% protein.	0.5 kg
Minced meat (50/50, beef/pork)	ICA Swedish, 21% fat whereof 9.2% saturated fat. 19% protein.	1 kg
Oregano	Santa Maria	5 g
Potatoes	ICA Swedish	1.2 kg
Rapeseed oil	Zeta	1 L
Rosemary	Santa Maria	21 g
Salt	Falksalt – with iodide	600 g
Spaghetti	Barilla	1 kg
Sugar	ICA	1 kg
Thyme	Santa Maria	15 g

Tomato puree	ICA	200 g
White pepper	Santa Maria	35 g
Yellow onion	ICA Swedish	500 g

TABLE A-14. INSTRUCTIONS FOR CHOSEN HOME RECIPES WITH MODIFICATIONS.

Ready meal product	Cooking instructions
Meatballs [55] (ICA classical recipe)	How to: 1. Mix milk and breadcrumbs. Let swell for 10 minutes. 2. Add minced meat, grated onion, egg, salt, pepper and sugar to the breadcrumbs mix. Work the mince smoothly. 3. Moisten your hands with cold water and shape meatballs. 4. Fry a few at a time in edible fat, shaking the pan from time to time so that the meatballs roll around and stay round. Feel free to use two frying pans. 5. Add a portion that you would like to eat (imagine that you have side dishes), let us know when you have done this. 6. Put the meatballs in foil tins and store in the refrigerator. Recommended side dishes: Boiled potatoes, mashed potatoes, lingonberry jam and pickles.
Potato mash [56] (Arla® basic recipe)	How to: 1. Boil lightly salted water. 2. Peel and cut the potatoes into smaller pieces. 3. Boil them soft for 10-15 minutes. Pour out the boiling water. 4. Heat the milk with butter in a saucepot and pour it over the potatoes. Whisk the mash lightly with an electric whisk. Season with salt and pepper. 5. Add a portion of mashed potatoes that you would like to eat, let us know when you have done this. 6. Add a portion of lingonberry jam that you would like to eat, let us know when you have done this. 7. Add a portion of pickles that you would like to eat, let us know when you have done this.
Pasta Bolognese [57] (ICA basic recipe)	How to: 1. Embrown the minced meat and vegetables in oil, add the tomato puree and embrown with it for a while. 2. Add crushed tomatoes, chicken broth and soy, cook slowly for 15 minutes, season with salt and pepper. 3. Cook the spaghetti according to the instructions on the package. 4. Add a portion of pasta that you would like to eat, let us know when you have done this. 5. Add a portion of sauce that you would like to eat, let us know when you have done this. 6. Add a portion of parmesan that you would like to eat, let us know when you have done this. Recommended side dishes: Parmesan cheese.

A.3.3 Industrial Recipes

[redacted]

[redacted]

A.4 Results

A.4.1 Raw Data Nutritional Content

The nutritional values originate from an external analysis performed by Eurofins, except the energy content which was performed using a bomb calorimeter at LTH. The number of significant digits varies and is based on the given numbers from the external nutrient analysis and from the bomb calorimeter. Treatment 1 (T1) refers to the homemade dish with an industrial recipe and treatment 2 (T2) refers to the homemade dish with a home recipe. The industrial-made dish with the same industrial recipe as T1 is called the control (C).

A.4.1.1 Raw Data Meatballs

TABLE A-16. RAW DATA FOR MEATBALLS.

ID	Energy (kJ/100g)	Protein (g/100g) ± 10%	Saturated fat (g/100g) *	Na (g/100g) ± 25%	NaCl (g/100g) **	Calcium (g/100g) ± 25%	Vitamin A, retinol (µg/100g) ***	Vitamin D3 (µg/100g) ***	Iron (g/100g) ± 25%	Potassium (g/100g) ± 25%	Magnesium (g/100g) ± 20%
M.C.1	1200 ± 23	13.1	7.46	0.65	1.62	0.023	LOQ1	LOQ2	0.0013	0.26	0.018
M.C.2	1200 ± 0.16	13.0	7.30	0.77	1.92	0.020	LOQ1	LOQ2	0.0011	0.25	0.016
M.T1.1	1300 ± 4.8	13.2	6.31	0.75	1.88	0.020	LOQ1	LOQ2	0.0013	0.27	0.018
M.T1.2	1300 ± 28	13.0	6.70	0.71	1.77	0.020	LOQ1	LOQ2	0.0011	0.25	0.017
M.T1.3	1300 ± 11	12.7	6.85	0.72	1.80	0.022	LOQ1	LOQ2	0.0012	0.25	0.016
M.T1.4	1200 ± 8.4	13.4	5.95	0.78	1.96	0.020	LOQ1	LOQ2	0.0013	0.28	0.018
M.T2.1	960 ± 5.0	16.4	5.48	0.54	1.36	0.036	LOQ1	LOQ2	0.0012	0.29	0.021
M.T2.2	1100 ± 4.6	17.6	5.61	0.62	1.56	0.043	LOQ1	LOQ2	0.0016	0.33	0.025
M.T2.3	1100 ± 11	17.4	6.49	0.53	1.32	0.035	LOQ1	LOQ2	0.0012	0.30	0.021
M.T2.4	1300 ± 83	16.2	7.39	0.21	0.52	0.041	LOQ1	0.638	0.0012	0.29	0.021

* Calculated value with different uncertainties, ranging from 10 to 20 %.
** Calculated from Na
*** Coverage factor 2

M.C.1 = Meatballs, Control 1
M.C.2 = Meatballs, Control 2

M.T1.1 = Meatballs, Treatment 1, Test subject 1
M.T1.2 = Meatballs, Treatment 1, Test subject 2
M.T1.3 = Meatballs, Treatment 1, Test subject 3
M.T1.4 = Meatballs, Treatment 1, Test subject 4

M.T2.1 = Meatballs, Treatment 2, Test subject 1
M.T2.2 = Meatballs, Treatment 2, Test subject 2
M.T2.3 = Meatballs, Treatment 2, Test subject 3
M.T2.4 = Meatballs, Treatment 2, Test subject 4

LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.250 µg/100g
LOQ3 = less than 5.00 µg/100g

A.4.1.2 Raw Data Potato Mash

TABLE A-17. RAW DATA FOR POTATO MASH.

ID	Energy (kJ/100g)	Protein (g/100g) ± 10%	Dietary fiber (g/100g) ± 15%	Saturated fat (g/100g) *	Na (g/100g) ± 25%	NaCl (g/100g) **	Calcium (g/100g) ± 25%	Vitamin C (g/100g) ***	Vitamin D3 (µg/100g) ***	Vitamin B9, folate (µg/100g) ***	Potassium (g/100g) ± 25%	Magnesium (g/100g) ± 20%
P.C.1	310 ± 1.9	1.48	<1.0	0.47	0.25	0.62	0.015	0.00157	LOQ2	LOQ3	0.28	0.015
P.C.2	310 ± 3.8	1.61	1.4	0.49	0.24	0.61	0.015	0.00119	LOQ2	LOQ3	0.25	0.014
P.T2.1	340 ± 8.7	1.75	<1.0	1.01	0.097	0.24	0.024	0.00285	LOQ2	LOQ3	0.24	0.014
P.T2.2	400 ± 4.2	1.72	1.0	1.73	0.23	0.58	0.025	0.00306	LOQ2	LOQ3	0.26	0.016
P.T2.3	330 ± 3.9	1.55	1.2	1.32	0.21	0.51	0.023	0.00294	LOQ2	LOQ3	0.21	0.014
P.T2.4	380 ± 0.37	1.56	1.2	1.37	0.16	0.39	0.019	0.00415	LOQ2	LOQ3	0.24	0.015

* Calculated value with different uncertainties, ranging from 10 to 20 %.
** Calculated from Na
*** Coverage factor 2

P.C.1 = Potato Mash, Control 1
P.C.2 = Potato Mash Control 2
P.T2.1 = Potato Mash, Treatment 2, Test subject 1
P.T2.2 = Potato Mash, Treatment 2, Test subject 2
P.T2.3 = Potato Mash, Treatment 2, Test subject 3
P.T2.4 = Potato Mash, Treatment 2, Test subject 4
LOQ1= less than 21.0 µg/100g
LOQ2 = less than 0.250 µg/100g
LOQ3 = less than 5.00 µg/100g

A.4.1.3 Raw Data Pasta Bolognese

TABLE A-18. RAW DATA PASTA BOLOGNESE.

ID	Energy (kJ/100g)	Protein (g/100g) ± 10%	Dietary fiber (g/100g) ± 15%	Saturated fat (g/100g) *	Na (g/100g) ± 25%	NaCl (g/100g) **	Calcium (g/100g) ± 25%	Vitamin A, retinol (µg/100g) ***	Beta-carotene (g/100g) ***	Beta-carotene, RE (g/100g) ***	Vitamin D3 (µg/100g) ***	Iron (g/100g) ± 25%	Potassium (g/100g) ± 25%	Magnesium (g/100g) ± 20%	Vitamin B9, folate (µg/100g) ***
B.C.1	560 ± 9.6	4.93	1.3	1.40	0.39	0.96	0.028	LOQ1	0.000237	0.0000395	LOQ2	0.00071	0.15	0.015	LOQ3
B.C.2	550 ± 41	5.36	1.5	1.53	0.45	1.13	0.031	LOQ1	0.000212	0.0000354	LOQ2	0.00058	0.16	0.014	LOQ3
B.T1.1	600 ± 16	5.38	1.6	1.85	0.46	1.15	0.033	LOQ1	0.000250	0.0000416	LOQ2	0.00067	0.18	0.016	LOQ3
B.T1.2	550 ± 14	5.29	1.4	1.68	0.44	1.10	0.033	LOQ1	0.000248	0.0000413	LOQ2	0.00069	0.17	0.015	LOQ3
B.T1.3	580 ± 5.1	5.44	1.5	1.78	0.45	1.11	0.032	LOQ1	0.000276	0.0000461	LOQ2	0.00062	0.17	0.016	LOQ3
B.T1.4	570 ± 16	5.39	1.4	1.63	0.41	1.03	0.030	LOQ1	0.000266	0.0000444	LOQ2	0.00065	0.16	0.015	LOQ3
B.T2.1	660 ± 28	7.56	2.0	1.22	0.47	1.17	0.021	LOQ1	0.000449	0.0000749	LOQ2	0.0011	0.20	0.022	LOQ3
B.T2.2	600 ± 24	7.12	1.9	1.02	0.45	1.13	0.015	LOQ1	0.000346	0.0000576	LOQ2	0.00090	0.18	0.017	LOQ3
B.T2.3	670 ± 11	8.19	1.7	1.05	0.35	0.88	0.015	LOQ1	0.000377	0.0000628	LOQ2	0.00083	0.19	0.019	LOQ3
B.T2.4	580 ± 28	7.94	1.6	1.27	0.23	0.59	0.016	LOQ1	0.000399	0.0000666	LOQ2	0.00088	0.22	0.018	LOQ3

* Calculated value with different uncertainties, ranging from 10 to 20 %.
** Calculated from Na
*** Coverage factor 2

B.C.1 = Bolognese Control 1
B.C.2 = Bolognese, Control 2
B.T1.1 = Bolognese, Treatment 1, Test subject 1
B.T1.2 = Bolognese, Treatment 1, Test subject 2
B.T1.3 = Bolognese, Treatment 1, Test subject 3
B.T1.4 = Bolognese, Treatment 1, Test subject 4
M.T2.1 = Bolognese, Treatment 2, Test subject 1
M.T2.2 = Bolognese, Treatment 2, Test subject 2
M.T2.3 = Bolognese, Treatment 2, Test subject 3
M.T2.4 = Bolognese, Treatment 2, Test subject 4
LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.250 µg/100g
LOQ3 = less than 5.00 µg/100g

A.4.1.4 Raw Data Portion Size

TABLE A-19. RAW DATA PORTION SIZE FOR ALL READY MEAL PRODUCTS.

ID	Portion size						
	Meatballs (g)	**Potato mash (g)**	**Pasta Bolognese**				
			Total (g)	Pasta (g)	Bolognese sauce (g)	Vegetables (g)	Mozzarella (g)
C.1	100*	200*	380*	150*	170*	52*	8*
C.2	100*	200*	380*	150*	170*	52*	8*
T1.1	98.90		361.2	146.8	106.0	85.5	22.9
T1.2	120.2		401.1	168.6	124.1	78.9	29.5
T1.3	118.6		394.5	153.4	148.5	68.5	24.1
T1.4	135.9		415.4	147.6	158.7	80.8	28.3
T2.1	135.9	171.2	540.2	273.9	266.3		
T2.2	163.8	156.7	459.9	252.3	207.6		
T2.3	174.2	221.4	477.3	214.7	262.6		
T2.4	207.0	228.7	371.1	133.0	238.1		

*Set values for one portion according to Orkla Foods, declared on the packaging.
C.1 = Control 1
C.2 = Control 2

T1.1 = Treatment 1, Test subject 1
T1.2 = Treatment 1, Test subject 2
T1.3 = Treatment 1, Test subject 3
T1.4 = Treatment 1, Test subject 4

T2.1 = Treatment 2, Test subject 1
T2.2 = Treatment 2, Test subject 2
T2.3 = Treatment 2, Test subject 3
T2.4 = Treatment 2, Test subject 4

A.4.2 Raw Data Complete Meals

The number of significant digits varies and is based on the given numbers from the external nutrient analysis and from the bomb calorimeter.

A.4.2.1 Meatballs and Potato Mash with Lingonberry Jam and Pickles

TABLE A-20. RAW DATA FOR COMPLETE HOMEMADE MEAL 1.

ID	Weight (g)	Energy (kJ)	Protein (g)	Dietary fiber (g)	Saturated fat (g)	Na (g)	NaCl (g)	Calcium (g)	Vitamin A, retinol (µg)	Vitamin C (mg)	Vitamin D3 (µg)	Vitamin B9, folate (µg)	Iron (mg)	Potassium (g)	Magnesium (g)	Added sugar (g)
P.T2.1	171.2	580	3.00	0*	1.73	0.17	0.41	0.041	-	4.88	LOQ2	LOQ3	-	0.41	0.024	0.0
M.T2.1	135.9	1300	22.3	-	7.45	0.73	1.9	0.049	LOQ1	-	LOQ2	-	1.6	0.39	0.029	0.55
L1	42.4	260	0.106	0.42	0.00	0.0049	0.020	0.0042	0.00	0.127	0.00	0.00	0.068	0.014	0.0011	0.0
P1	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CM.1	**349.5**	**2100**	**25.4**	**0.42**	**9.18**	**0.91**	**2.3**	**0.094**	**0.00**	**5.00**	**0.00**	**0.00**	**2.7**	**0.82**	**0.054**	**0.55**
P.T2.2	156.7	620	2.70	1.6	2.71	0.36	0.91	0.039	-	4.80	LOQ2	LOQ3	-	0.41	0.025	0.0
KH2	163.8	1800	28.8	-	9.19	1.0	2.6	0.070	LOQ1	-	LOQ2	-	2.6	0.54	0.041	0.47
L2	31.3	190	0.0783	0.31	0.00	0.0036	0.015	0.00031	0.00	0.0939	0.00	0.00	0.050	0.010	0.00078	0.0
P2	30.4	19	0.274	0.55	0.0213	0.43	1.1	0.0052	0.00	0.00	0.00	0.00	0.061	0.036	0.0030	0.0
CM.2	**382.2**	**2600**	**31.9**	**2.4**	**11.9**	**1.8**	**4.5**	**0.12**	**0.00**	**4.89**	**0.00**	**0.00**	**2.7**	**0.99**	**0.070**	**0.47**
P.T2.3	221.4	740	3.43	2.7	2.92	0.46	1.1	0.051	-	6.51	LOQ2	LOQ3	-	0.46	0.031	0.0
K.T2.3	174.2	1900	30.3	-	11.3	0.92	2.3	0.061	LOQ1	-	LOQ2	-	2.1	0.52	0.037	0.48
L3	31.6	200	0.0790	0.32	0.00	0.0036	0.015	0.0031	0.00	0.0948	0.00	0.00	0.051	0.010	0.00079	0.0
P3	32.9	20	0.296	0.59	0.0230	0.46	1.2	0.0056	0.00	0.00	0.00	0.00	0.066	0.039	0.0033	0.0
CM.3	**460.1**	**2800**	**34.1**	**3.6**	**14.3**	**1.9**	**4.6**	**0.12**	**0.00**	**6.60**	**0.00**	**0.00**	**2.2**	**1.04**	**0.072**	**0.48**
P.T2.4	228.7	860	3.57	2.7	3.13	0.37	0.89	0.043	-	9.40	LOQ2	LOQ3	-	0.55	0.034	0.0
K.T2.4	207.0	2600	33.5	-	15.3	0.43	1.1	0.085	LOQ1	-	1.32	-	2.5	0.60	0.043	0.0
L4	55.0	340	0.138	0.55	0.00	0.0063	0.026	0.0054	0.00	0.165	0.00	0.00	0.088	0.018	0.0014	0.0
P4	71.8	44	0.656	1.3	0.0503	1.0	2.5	0.012	0.00	0.00	0.00	0.00	0.14	0.085	0.0072	0.0
CM.4	**562.5**	**3900**	**37.9**	**4.6**	**18.5**	**1.8**	**4.5**	**0.15**	**0.00**	**9.66**	**0.00**	**0.00**	**2.7**	**1.3**	**0.086**	**0.0**
Mean	438.6	2900	32.3	2.8	13.5	1.6	4.0	0.12	0.00	6.54	0.00	0.00	2.3	1.0	0.070	0.37
Std	94.8	730	5.24	1.8	3.94	0.46	1.1	0.021	0.00	2.22	0.00	0.00	0.49	0.18	0.013	0.25

* Set to zero due to less than 1.0 g/100g
P.T2. (1,2,3,4) = Potato Mash, Treatment 2 (Test subject number)
M.T2. (1,2,3,4) = Meatballs, Treatment 2 (Test subject number)
CM. (1,2,3,4) = Complete Meal (Test subject number)
L (1,2,3,4) = Lingonberry Jam (Test subject number)
P (1,2,3,4) = Pickles (Test subject number)
LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.259 µg/100g
LOQ3 = less than 5.00 µg/100g

TABLE A-21. RAW DATA FOR COMPLETE CONTROL MEAL 1.

ID	Weight (g)	Energy (kJ)	Protein (g)	Dietary fiber (g)	Saturated fat (g)	Na (g)	NaCl (g)	Calcium (g)	Vitamin A, retinol (µg)	Vitamin C (mg)	Vitamin D3 (µg)	Vitamin B9, folate (µg)	Iron (mg)	Potassium (g)	Magnesium (g)	Added sugar (g)
P.C.1	200*	620	2.96	0**	0.940	0.50	1.2	0.030	-	3.14	LOQ2	LOQ3	-	0.56	0.030	0.0
M.C.1	100*	1200	13.1	-	7.46	0.65	1.6	0.023	LOQ1	-	LOQ2	-	1.3	0.26	0.018	0.0
L	40.1	250	0.100	0.40	0.00	0.0046	0.019	0.0040	0.00	0.120	0.00	0.00	0.064	0.013	0.0010	0.0
P	33.8	21	0.304	0.61	0.0236	0.47	1.2	0.0057	0.00	0.00	0.00	0.00	0.068	0.040	0.0034	0.0
CM.1	**374**	**2100**	**16.5**	**1.0**	**8.42**	**1.6**	**4.1**	**0.063**	**0.00**	**3.26**	**0.00**	**0.00**	**1.4**	**0.87**	**0.052**	**0.0**
P.C.2	200*	620	3.22	2.8	0.980	0.48	1.2	0.030	-	2.38	LOQ2	LOQ3	-	0.50	0.028	0.0
M.C.2	100*	1200	13.0	-	7.30	0.77	1.9	0.020	LOQ1	-	LOQ2	-	1.1	0.25	0.016	0.0
L	40.1	250	0.100	0.40	0.00	0.0046	0.019	0.0040	0.00	0.120	0.00	0.00	0.064	0.013	0.0010	0.0
P	33.8	21	0.304	0.61	0.0236	0.47	1.2	0.0057	0.00	0.00	0.00	0.00	0.068	0.040	0.0034	0.0
CM.2	**374**	**2100**	**16.6**	**3.8**	**8.30**	**1.7**	**4.3**	**0.060**	**0.00**	**2.50**	**0.00**	**0.00**	**1.2**	**0.80**	**0.048**	**0.0**
Mean	374	2100	16.5	2.4	8.36	1.7	4.2	0.061	0.00	2.88	0.00	0.00	1.3	0.84	0.05	0.0
Std	0.00	3.1	0.113	2.0	0.0849	0.07	0.20	0.0021	0.00	0.537	0.00	0.00	0.14	0.049	0.0028	0.0

* Set value from the package of the ready meal
** Set to zero due to less than 1.0 g/100g
P.C. (1,2) = Potato Mash, Control (Number)
M.C. (1,2) = Meatballs, Control (Number)
L = Lingonberry Jam (Average)
P = Pickles (Average)
CM. (1,2) = Complete Meal (Control number)
LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.259 µg/100g
LOQ3 = less than 5.00 µg/100g

A.4.2.2 Pasta Bolognese with Parmesan Cheese

TABLE A-22. RAW DATA FOR COMPLETE HOMEMADE_MEAL 2.

ID	Weight (g)	Energy (kJ)	Protein (g)	Dietary fiber (g)	Saturated fat (g)	Na (g)	NaCl (g)	Calcium (g)	Vitamin A, retinol (µg)	Beta-carotene (mg)	Beta-carotene, RE (mg)	Vitamin D3 (µg)	Iron (mg)	Potassium (g)	Magn-esium (g)	Vitamin B9, folate (µg)	Added sugar (g)
B.T2.1	540.2	3600	40.8	11	6.59	2.5	6.3	0.11	LOQ1	2.43	0.405	LOQ2	5.9	1.08	0.12	LOQ3	0.0
PC.1	8.7	160	3.61	0.0	1.69	0.087	0.22	0.12	0.00	0.00931	0.0212	0.00	0.087	0.01	0.0044	0.00	0.0
CM.1	**548.9**	**3800**	**44.5**	**11**	**8.28**	**2.6**	**6.5**	**0.23**	**0.00**	**2.44**	**0.426**	**0.00**	**6.0**	**1.09**	**0.12**	**0.00**	**0.0**
B.T2.2	459.9	2800	32.7	8.7	4.69	2.1	5.2	0.069	LOQ1	1.52	0.265	LOQ2	4.1	0.83	0.078	LOQ3	0.0
PC.2	15.0	280	6.23	0.0	2.92	0.15	0.38	0.21	0.00	0.0161	0.0366	0.00	0.15	0.02	0.0077	0.00	0.0
CM.2	**474.9**	**3000**	**39.0**	**8.7**	**7.61**	**2.2**	**5.6**	**0.28**	**0.00**	**1.61**	**0.301**	**0.00**	**4.3**	**0.84**	**0.086**	**0.00**	**0.0**
B.T2.3	477.3	3200	39.1	8.1	5.01	1.7	4.2	0.072	LOQ1	1.80	0.300	LOQ2	4.0	0.91	0.091	LOQ3	0.0
PC.3	8.4	160	3.49	0.0	1.63	0.084	0.21	0.12	0.00	0.00899	0.0205	0.00	0.084	0.01	0.0043	0.00	0.0
CM.3	**485.7**	**3400**	**42.6**	**8.1**	**6.65**	**1.7**	**4.4**	**0.19**	**0.00**	**1.81**	**0.320**	**0.00**	**4.0**	**0.92**	**0.095**	**0.00**	**0.0**
BT2.4	371.1	2200	29.5	5.9	4.71	0.85	2.2	0.059	LOQ1	1.48	0.247	LOQ2	3.3	0.82	0.067	LOQ3	0.96
PC.4	7.3	140	3.03	0.0	1.42	0.073	0.18	0.10	0.00	0.00781	0.0178	0.00	0.073	0.01	0.0037	0.00	0.0
CM.4	**378.4**	2300	**32.5**	**5.9**	**6.13**	**0.93**	**2.4**	**0.16**	**0.00**	**1.49**	**0.265**	**0.00**	**3.3**	**0.82**	**0.071**	**0.00**	**0.96**
Mean	472.0	3100	39.6	8.4	7.17	1.9	4.7	0.21	0.00	1.84	0.328	0.00	4.4	0.92	0.094	0.00	0.24
Std	70.4	620	5.27	2.0	0.963	0.73	1.8	0.051	0.00	0.421	0.0691	0.00	1.1	0.12	0.022	0.00	0.48

B.T2. (1,2,3,4) = Bolognese, Treatment 2 (Test subject number)
PC. (1,2,3,4) = Parmesan Cheese (Test subject number)
CM. (1,2,3,4) = Complete Meal (Test subject number)
LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.250 µg/100g
LOQ3 = less than 5.00 µg/100g

TABLE A-23. RAW DATA FOR COMPLETE CONTROL MEAL 2.

ID	Weight (g)	Energy (kJ)	Protein (g)	Dietary fiber (g)	Satura-ted fat (g)	Na (g)	NaCl (g)	Calcium (g)	Vitamin A, retinol (µg)	Beta-carotene (mg)	Beta-carotene, RE (mg)	Vitamin D3 (µg)	Iron (mg)	Potassium (g)	Magn-esium (g)	Vitamin B9, folate (µg)	Added sugar (g)
B.C.1	380*	2100	18.7	4.9	5.32	1.5	3.7	0.11	LOQ1	0.901	0.150	LOQ2	2.7	0.57	0.057	LOQ3	0.0
B.C.2	380*	2100	20.4	5.7	5.81	1.7	4.3	0.12	LOQ1	0.806	0.135	LOQ2	2.2	0.61	0.053	LOQ3	0.0
PC	9.9	190	4.09	0.0	1.92	0.10	0.25	0.14	0.00	0.0105	0.0240	0.00	0.099	0.01	0.0050	0.00	0.0
Mean w/o PC	380	2100	19.6	5.3	5.57	1.6	4.0	0.11	0.00	0.853	0.142	0.00	2.5	0.59	0.055	0.00	0.0
Mean w/ PC	389.9	2300	23.6	5.3	7.48	1.7	4.2	0.25	0.00	0.864	0.166	0.00	2.6	0.60	0.060	0.00	0.0

* Set value from the package of the ready meal
B.C. (1,2) = Bolognese, Control (Number)
PC = Parmesan Cheese (Average)
CM. (1,2) = Complete Meal (Control number)
LOQ1 = less than 21.0 µg/100g
LOQ2 = less than 0.250 µg/100g
LOQ3 = less than 5.00 µg/100g

A.4.3 NRF11.3 Indices Nutritional Contents

A.4.3.1 Per 100 g

TABLE A-24. MEATBALLS NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 GRAMS.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				**NRF Index**
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
M.C.1	27	*	**	*	**	*	3	11	6	8	54	34	0	27	61	-7
M.C.2	27	*	**	*	**	*	3	9	5	8	51	33	0	32	65	-14
M.T1.1	27	*	**	*	**	*	3	11	6	8	54	29	0	31	60	-6
M.T1.2	27	*	**	*	**	*	3	9	5	8	51	30	0	30	60	-9
M.T1.3	26	*	**	*	**	*	3	10	5	8	51	31	0	30	61	-10
M.T1.4	27	*	**	*	**	*	3	11	6	8	55	27	0	33	60	-5
M.T2.1	33	*	**	*	**	*	5	10	7	9	63	25	0.8	23	48	15
M.T2.2	36	*	**	*	**	*	5	13	8	10	73	26	0.6	26	52	20
M.T2.3	36	*	**	*	**	*	4	10	7	9	66	30	0.6	22	52	14
M.T2.4	33	*	**	*	6	*	5	10	7	9	70	34	0	9	42	28

* Not analyzed
** Values set to zero due to sensitivity analysis

M.C.1 = Meatballs, Control 1
M.C.2 = Meatballs, Control 2

M.T1.1 = Meatballs, Treatment 1, Test subject 1
M.T1.2 = Meatballs, Treatment 1, Test subject 2
M.T1.3 = Meatballs, Treatment 1, Test subject 3
M.T1.4 = Meatballs, Treatment 1, Test subject 4

M.T2.1 = Meatballs, Treatment 2, Test subject 1
M.T2.2 = Meatballs, Treatment 2, Test subject 2
M.T2.3 = Meatballs, Treatment 2, Test subject 3
M.T2.4 = Meatballs, Treatment 2, Test subject 4

TABLE A-25. POTATO MASH NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 GRAMS.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				**NRF Index**
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
P.C.1	3	**	*	2	**	**	2	*	5	8	20	2	0	10	12	8
P.C.2	3	6	*	2	**	**	2	*	4	8	24	2	0	10	12	12
P.T2.1	4	**	*	4	**	**	3	*	4	7	22	5	0	7	12	10
P.T2.2	4	4	*	4	**	**	3	*	5	8	28	8	0	10	18	10
P.T2.3	3	5	*	4	**	**	3	*	4	6	26	6	0	9	15	11
P.T2.4	3	5	*	6	**	**	2	*	5	7	28	6	0	7	13	15

* Not analyzed
** Values set to zero due to sensitivity analysis

P.C.1 = Potato Mash, Control 1
P.C.2 = Potato Mash Control 2

P.T2.1 = Potato Mash, Treatment 2, Test subject 1
P.T2.2 = Potato Mash, Treatment 2, Test subject 2

P.T2.3 = Potato Mash, Treatment 2, Test subject 3
P.T2.4 = Potato Mash, Treatment 2, Test subject 4

TABLE A-26. PASTA BOLOGNESE NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 GRAMS.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
B.C.1	10	5	5	*	**	**	4	6	5	5	39	6	0	16	22	17
B.C.2	11	6	4	*	**	**	4	5	4	5	39	7	0	19	26	14
B.T1.1	11	6	5	*	**	**	4	6	5	5	43	8	0	19	28	15
B.T1.2	11	6	5	*	**	**	4	6	5	5	41	8	0	18	26	15
B.T1.3	11	6	6	*	**	**	4	5	5	5	42	8	0	19	27	16
B.T1.4	11	6	6	*	**	**	4	5	5	5	41	7	0	17	25	16
B.T2.1	15	8	9	*	**	**	3	9	7	6	58	6	0	20	25	33
B.T2.2	15	8	7	*	**	**	2	8	5	5	50	5	0	19	23	26
B.T2.3	17	7	8	*	**	**	2	7	6	6	52	5	0	15	19	33
B.T2.4	16	6	8	*	**	**	2	7	6	7	53	6	0.5	10	16	37

* Not analyzed
** Values set to zero due to sensitivity analysis
B.C.1 = Bolognese Control 1
B.C.2 = Bolognese, Control 2
B.T1.1 = Bolognese, Treatment 1, Test subject 1
B.T1.2 = Bolognese, Treatment 1, Test subject 2
B.T1.3 = Bolognese, Treatment 1, Test subject 3
B.T1.4 = Bolognese, Treatment 1, Test subject 4
M.T2.1 = Bolognese, Treatment 2, Test subject 1
M.T2.2 = Bolognese, Treatment 2, Test subject 2
M.T2.3 = Bolognese, Treatment 2, Test subject 3
M.T2.4 = Bolognese, Treatment 2, Test subject 4

A.4.3.2 Per Portion

TABLE A-27. MEATBALLS NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER PORTION.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
M.C.1	27	*	**	*	**	*	3	11	6	8	54	34	0	27	61	-7
M.C.2	27	*	**	*	**	*	3	9	5	8	51	33	0	32	65	-14
M.T1.1	27	*	**	*	**	*	2	11	6	8	54	28	0	31	59	-6
M.T1.2	32	*	**	*	**	*	3	11	6	9	62	36	0	35	72	-10
M.T1.3	31	*	**	*	**	*	3	12	6	9	61	37	0	36	73	-12
M.T1.4	37	*	**	*	**	*	3	15	8	12	75	37	0	44	81	-7
M.T2.1	46	*	**	*	**	*	6	14	9	12	86	34	1	31	66	20
M.T2.2	59	*	**	*	**	*	9	22	13	16	119	42	1	43	85	34
M.T2.3	62	*	**	*	**	*	8	17	12	16	114	51	1	38	91	24
M.T2.4	68	*	**	*	13	*	11	21	14	18	145	70	0	18	87	57

* Not analyzed
** Values set to zero due to sensitivity analysis

M.C.1 = Meatballs, Control 1
M.C.2 = Meatballs, Control 2

M.T1.1 = Meatballs, Treatment 1, Test subject 1
M.T1.2 = Meatballs, Treatment 1, Test subject 2
M.T1.3 = Meatballs, Treatment 1, Test subject 3
M.T1.4 = Meatballs, Treatment 1, Test subject 4

M.T2.1 = Meatballs, Treatment 2, Test subject 1
M.T2.2 = Meatballs, Treatment 2, Test subject 2
M.T2.3 = Meatballs, Treatment 2, Test subject 3
M.T2.4 = Meatballs, Treatment 2, Test subject 4

TABLE A-28. POTATO MASH NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER PORTION.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
P.C.1	6	**	*	4	**	**	4	*	10	17	40	4	0	21	25	16
P.C.2	7	11	*	3	**	**	4	*	9	15	49	4	0	20	25	24
P.T2.1	6	**	*	7	**	**	5	*	8	12	38	8	0	7	15	23
P.T2.2	6	6	*	6	**	**	5	*	8	12	43	12	0	15	27	16
P.T2.3	7	11	*	9	**	**	6	*	10	14	57	13	0	19	32	25
P.T2.4	7	11	*	13	**	**	5	*	11	17	64	14	0	15	29	35

* Not analyzed
** Values set to zero due to sensitivity analysis

P.C.1 = Potato Mash, Control 1
P.C.2 = Potato Mash Control 2

P.T2.1 = Potato Mash, Treatment 2, Test subject 1
P.T2.2 = Potato Mash, Treatment 2, Test subject 2

P.T2.3 = Potato Mash, Treatment 2, Test subject 3
P.T2.4 = Potato Mash, Treatment 2, Test subject 4

TABLE A-29. PASTA BOLOGNESE NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER PORTION.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
B.C.1	38	20	19	*	**	**	13	22	18	17	148	24	0	61	85	63
B.C.2	42	23	17	*	**	**	15	18	17	18	150	26	0	72	98	52
B.T1.1	40	23	19	*	**	**	15	20	18	20	155	30	0	69	100	55
B.T1.2	43	22	21	*	**	**	17	23	19	21	166	31	0	74	104	62
B.T1.3	44	24	23	*	**	**	16	20	20	20	167	32	0	73	105	62
B.T1.4	46	23	23	*	**	**	16	23	20	20	170	31	0	71	102	68
B.T2.1	83	43	51	*	**	**	14	50	38	33	311	30	0	105	135	176
B.T2.2	67	35	33	*	**	**	9	34	25	25	228	21	0	87	108	120
B.T2.3	80	32	37	*	**	**	9	33	29	27	248	23	0	70	93	155
B.T2.4	60	24	31	*	**	**	7	27	21	25	195	21	2	36	60	135

* Not analyzed
** Values set to zero due to sensitivity analysis
B.C.1 = Bolognese Control 1
B.C.2 = Bolognese, Control 2

B.T1.1 = Bolognese, Treatment 1, Test subject 1
B.T1.2 = Bolognese, Treatment 1, Test subject 2
B.T1.3 = Bolognese, Treatment 1, Test subject 3
B.T1.4 = Bolognese, Treatment 1, Test subject 4

M.T2.1 = Bolognese, Treatment 2, Test subject 1
M.T2.2 = Bolognese, Treatment 2, Test subject 2
M.T2.3 = Bolognese, Treatment 2, Test subject 3
M.T2.4 = Bolognese, Treatment 2, Test subject 4

A.4.3.3 Per 100 kcal

TABLE A-30. MEATBALLS NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 KCAL.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
M.C.1	9	*	**	*	**	*	1	4	2	3	19	12	0	9	21	-2
M.C.2	9	*	**	*	**	*	1	3	2	3	18	12	0	11	23	-5
M.T1.1	9	*	**	*	**	*	1	4	2	3	18	10	0	10	20	-2
M.T1.2	9	*	**	*	**	*	1	3	2	2	17	10	0	10	20	-3
M.T1.3	9	*	**	*	**	*	1	3	2	2	17	10	0	10	20	-3
M.T1.4	9	*	**	*	**	*	1	4	2	3	19	9	0	11	20	-2
M.T2.1	15	*	**	*	**	*	2	4	3	4	28	11	0.5	10	21	7
M.T2.2	14	*	**	*	**	*	2	5	3	4	28	10	0.2	10	20	8
M.T2.3	14	*	**	*	**	*	2	4	3	4	26	12	0.2	9	20	5
M.T2.4	11	*	**	*	2	*	2	3	2	3	23	11	0	3	14	9

* Not analyzed
** Values set to zero due to sensitivity analysis

M.C.1 = Meatballs, Control 1
M.C.2 = Meatballs, Control 2

M.T1.1 = Meatballs, Treatment 1, Test subject 1
M.T1.2 = Meatballs, Treatment 1, Test subject 2
M.T1.3 = Meatballs, Treatment 1, Test subject 3
M.T1.4 = Meatballs, Treatment 1, Test subject 4

M.T2.1 = Meatballs, Treatment 2, Test subject 1
M.T2.2 = Meatballs, Treatment 2, Test subject 2
M.T2.3 = Meatballs, Treatment 2, Test subject 3
M.T2.4 = Meatballs, Treatment 2, Test subject 4

TABLE A-31. POTATO MASH NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 KCAL.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
P.C.1	4	**	*	3	**	**	3	*	6	11	27	3	0	14	17	11
P.C.2	4	8	*	2	**	**	3	*	6	10	33	4	0	14	17	16
P.T2.1	4	**	*	5	**	**	4	*	6	9	27	6	0	5	11	17
P.T2.2	4	4	*	4	**	**	3	*	5	8	29	8	0	10	18	11
P.T2.3	4	6	*	5	**	**	4	*	6	8	32	8	0	11	18	14
P.T2.4	4	5	*	6	**	**	3	*	5	8	31	7	0	7	14	17

* Not analyzed
** Values set to zero due to sensitivity analysis

P.C.1 = Potato Mash, Control 1
P.C.2 = Potato Mash Control 2

P.T2.1 = Potato Mash, Treatment 2, Test subject 1
P.T2.2 = Potato Mash, Treatment 2, Test subject 2

P.T2.3 = Potato Mash, Treatment 2, Test subject 3
P.T2.4 = Potato Mash, Treatment 2, Test subject 4

TABLE A-32. PASTA BOLOGNESE NRF INDEX FOR EACH NRF NUTRIENT AND SUMS – PER 100 KCAL.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A	Vit C	Vit D	Folate	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
B.C.1	8	4	4	*	**	**	3	4	4	3	29	5	0	12	17	12
B.C.2	8	5	3	*	**	**	3	4	3	4	30	5	0	14	20	10
B.T1.1	8	4	4	*	**	**	3	4	4	4	30	6	0	13	19	11
B.T1.2	8	4	4	*	**	**	3	4	4	4	31	6	0	14	20	12
B.T1.3	8	4	4	*	**	**	3	4	4	4	31	6	0	13	19	11
B.T1.4	8	4	4	*	**	**	3	4	3	4	30	5	0	13	18	12
B.T2.1	10	5	6	*	**	**	2	6	4	4	36	3	0	12	16	21
B.T2.2	10	5	5	*	**	**	1	5	4	4	35	3	0	13	16	18
B.T2.3	10	4	5	*	**	**	1	4	4	4	32	3	0	9	12	20
B.T2.4	12	5	6	*	**	**	1	5	4	5	38	4	0.4	7	12	26

* Not analyzed
** Values set to zero due to sensitivity analysis
B.C.1 = Bolognese Control 1
B.C.2 = Bolognese, Control 2
B.T1.1 = Bolognese, Treatment 1, Test subject 1
B.T1.2 = Bolognese, Treatment 1, Test subject 2
B.T1.3 = Bolognese, Treatment 1, Test subject 3
B.T1.4 = Bolognese, Treatment 1, Test subject 4
M.T2.1 = Bolognese, Treatment 2, Test subject 1
M.T2.2 = Bolognese, Treatment 2, Test subject 2
M.T2.3 = Bolognese, Treatment 2, Test subject 3
M.T2.4 = Bolognese, Treatment 2, Test subject 4

A.4.4 NRF11.3 Indices Complete Meals

A.4.4.1 Meatballs and Potato Mash with Lingonberry Jam and Pickles

TABLE A-33. THE TEST SUBJECTS' NRF INDEX FOR EACH NRF NUTRIENT AND SUMS - COMPLETE HOME MEAL 1.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A*	Vit C	Vit D	Folate*	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
1	52	2		7	0		12	14	17	25	128	42	1	38	81	47
2	65	10		7	0		15	23	22	30	171	54	1	76	131	40
3	70	14		9	0		15	18	23	31	180	65	1	77	142	38
4	77	18		13	13		18	23	27	38	228	84	0	75	159	69
Mean	66	11		9	3		15	19	22	31	177	61	1	66	128	49
Std	11	7		3	7		3	4	4	5	41	18	1	19	34	14

* Value set to zero due to sensitivity analysis, hence no theoretically calculated values for the side dishes.

TABLE A-34. THE CONTROLS' NRF INDEX FOR EACH NRF NUTRIENT AND SUMS - COMPLETE CONTROL MEAL 1.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				NRF Index
	Protein	Fiber	Vit A*	Vit C	Vit D	Folate*	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
1	34	4		4	0		8	12	17	26	105	38	0	68	106	-1
2	34	15		3	0		7	10	15	24	110	38	0	72	110	0
Mean	34	10		4	0		8	11	16	25	107	38	0	70	108	-1
Std	0	8		1	0		0	1	1	1	4	0	0	3	3	1

* Value set to zero due to sensitivity analysis, hence no theoretically calculated values for the side dishes.

A.4.4.2 Pasta Bolognese with Parmesan Cheese

TABLE A-35. THE TEST SUBJECTS' NRF INDEX FOR EACH NRF NUTRIENT AND SUMS - COMPLETE HOME MEAL 2.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				**NRF Index**
	Protein	Fiber	Vit A	Vit C*	Vit D**	Folate **	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
1	91	43	53				29	50	39	33	339	38	0	109	147	192
2	80	35	38				34	36	27	26	275	35	0	93	127	148
3	87	32	40				23	34	30	28	274	30	0	74	104	171
4	66	24	33				20	28	22	25	218	28	2	40	69	149
Mean	81	34	41				27	37	30	28	277	33	0	79	112	165
Std	11	8	9				6	10	7	4	49	4	1	30	33	21

* Not analyzed.
**Values set to zero due to sensitivity analysis, hence no theoretically calculated values for the side dish.

TABLE A-36. THE CONTROLS' NRF INDEX FOR EACH NRF NUTRIENT AND SUMS - COMPLETE CONTROL MEAL 2.

No.	Nutrients to encourage (based on minimum RDI)											Nutrients to limit (based on MRI)				**NRF Index**
	Protein	Fiber	Vit A	Vit C*	Vit D**	Folate **	Calcium	Iron	Magnesium	Potassium	Sum Encourage	Saturated fat	Added Sugar	Salt	Sum Limit	
1	38	20	19				13	22	18	17	148	24	0	61	85	63
2	42	23	17				15	18	17	18	150	26	0	72	98	53
Mean	40	21	18				14	20	17	18	149	25	0	66	91	57
Std	2	2	1				1	3	1	1	1	2	0	8	9	8

* Not analyzed.
**Values set to zero due to sensitivity analysis, hence no theoretically calculated values for the side dish.