Master thesis

Public health nutrition

May 2020

NUTRIENT CONTENT IN GLUTEN FREE AND GLUTEN CONTAINING PRODUCTS

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PREFACE

The last year has been educational, interesting and exciting. This period has consisted of both ups and downs, but in the end I´m proud of the results of our study. I am so very glad that I got to write a master thesis that I had a big personal interest in. I feel certain that the results of this master thesis will be important for all of us with celiac disease in the years to come.

I would first like to thank my internal supervisors, Vibeke H. Telle-Hansen (Associate Professor at Oslo Metropolitan University) and Mari Myhrstad (Associate Professor at Oslo Metropolitan University). Thank you for giving me the opportunity to attend in this research project, and for all your guidance, patience and support through this year.

I would also like to thank my external supervisor, Christine Henriksen (Associate Professor at University of Oslo), for all your knowledge about celiac disease and gluten free food, and for valuable guidance along the journey. And I would like to thank Monica J. Hellmann (Owner of "Det Glutenfrie Verksted"), thank you for all your expertise on the gluten free food marked and advices on the "gluten free language".

Finally, I would like to thank my family, friends and fellow student who have always believed in me and my study, and for their support, good conversations, and encouragement.

Oslo, May 2020

Marlene Mari Slydahl

ABSTRACT

Background: Gluten free diet is the only treatment for persons with celiac disease. In recent years the interest for gluten free products has increased and gluten free products are perceived to be a healthier alternative than gluten containing products. The nutrient composition of gluten free products in Norway has not previously been investigated.

Aim: The objective of this study was to characterize the nutrient content and price of gluten free products in Norwegian grocery stores.

Materials and method: Gluten free and gluten containing products (767 in total) were collected in three web-based and five grocery stores in Oslo and Viken. The nutrient content of 427 unique gluten free items were compared with 340 similar gluten containing products. In addition, two different reference diets were developed to compare intake on macronutrients and fiber: one based on the recommendations for wholegrains and fiber, and the other based on a nationwide dietary survey named (Norkost 3). Labelled nutrient content of total energy, macronutrients and salt per 100 gram of product, and price per 1000 gram of product were compared in gluten free versus gluten containing products with non-parametric statistical methods.

Results: Overall, gluten free products contained significantly less protein (median 5.8/9.5) and dietary fiber (median 4.4/5.9), and significantly more carbohydrates (median 61/58), saturated fat (median 1.0/0.9) and salt (median (IQR) 0.7 (0.2-1.2)/0.7 (0.1-1.0)) than their gluten containing counterparts. Our results from the reference diets showed that gluten free diets based on products with high content of fiber provides more dietary fiber to the diet than in Norkost 3. Gluten free diets based on products with lowest price provides less fiber and more sugar than in Norkost 3. Gluten free products were on average 118% more expensive than their gluten containing counterparts were.

Conclusion: The present study indicates that there are significant differences in nutrient content of gluten free products compared to gluten containing products, and that the costs of gluten free products are higher than gluten containing products. Healthy persons without any gluten related disease should avoid consuming a gluten free diet.

SAMMENDRAG

Bakgrunn: Glutenfritt kosthold er den eneste behandlingen for personer med cøliaki. Gjennom de siste årene har interessen og salgstallene på glutenfrie matvarer økt og glutenfrie matvarer antas å være et sunnere alternativ sammenlignet med glutenholdige produkter. Næringsinnhold i glutenfrie produkter har ikke blitt undersøkt tidligere i Norge

Hensikt: Hensikten med denne studien var å gi en oversikt over næringsinnhold og pris i/på glutenfrie produkter i norske dagligvarebutikker.

Metode: Fra en database med 767 produkter samlet inn fra tre nettsider og fem fysiske matbutikker, har vi sammenlignet næringsinnhold i 427 unike glutenfrie produkter med 340 sammenlignbare glutenholdige produkter. To ulike referansekosthold ble utviklet for å undersøke om det er mulig å innta anbefalt mengde av makronæringsstoff og fiber i et glutenfritt kosthold. Det ene referansekostholdet er basert på anbefalingene på inntak av fullkorn, og det andre referansekostholdet er basert på tall fra den nasjonale kostholdsundersøkelsen Norkost 3. Innehold av energi, totalt fett, mettet fett, karbohydrater, sukker, kostfiber, protein og salt per 100 gram vare, og pris per 1000 gram vare ble sammenlignet mellom glutenfrie og glutenholdige produkter med ikke-parametriske statistiske metoder.

Resultat: Glutenfrie produkter inneholdt signifikant mindre protein (median 5.8/9.5) og kostfiber (median 4.4/5.9), og mer karbohydrater (median 61/58), mettet fett (median 1.0/0.9) og salt (median (IQR) 0.7 (0.2-1.2)/0.7 (0.1-1.0)) sammenlignet med glutenholdige produkter. Resultatene fra referansekostholdene viste at et glutenfritt kosthold basert på produkter med høyt fiberinnhold gir mer kostfiber sammenlignet med Norkost 3. Et glutenfritt kosthold basert på produkter med lavest pris gir mindre fiber og mer sukker sammenlignet med Norkost 3. I gjennomsnitt var glutenfrie produkter 118% dyrere enn sammenlignbare glutenholdige produkter.

Konklusjon: Denne studien indikerer at det er signifikante forskjeller i næringsinnhold i glutenfrie produkter sammenlignet med glutenholdige produkter, og at kostnadene for glutenfrie produkter er høyere enn for glutenholdige produkter. Friske personer uten gluten relatert sykdom bør unngå å ha et glutenfritt kosthold.

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Abbreviations

GF: Gluten free

CD: Celiac Disease

NCGS: Non-Celiac Gluten Sensitivity

WA: Wheat Allergy

FOODMAPS: Fermentable Oligosaccharides, Disaccharides, Monosaccharides And Polyols

IgG anti-EMA: Immunoglobulin G Anti-endomysial antibody

IgA anti-tTG: Immunoglobulin A anti-transglutaminase

IgG anti-DGP: Immunoglobulin G anti-deaminated gliadin protein epitopes

IgA Anti-gliadin: Immunoglobulin A Anti-gliadin

IgE: Immunoglobulin E

PPM: Parts Per Million

WHO: World Health Organization

CVD: Cardiovascular disease

T1D: Type 1 Diabetes

T2D: Type 2 Diabetes

IQR: Interquartile Range

EFSA: European Food Safety Authority

ESPGHAN: The European for Peadiatric Gastroenterology, Hepatology and Nutrition

1 INTRODUCTION

Gluten-related disorders affects millions of peoples worldwide and the number of people following a gluten free (GF) diet is rising (Dieterich & Zopf, 2019). Three conditions require treatment with a GF diet: celiac disease (CD), non-celiac gluten-sensitivity (NCGS) and wheat allergy (WA) (Melini, Melini, & Melini, 2019). CD is a chronic autoimmune disease and is the gluten-related disease we have most knowledge about. The only treatment for CD is a lifelong GF diet (De Re, Magris, Cannizzaro, & De Re, 2017). When diagnosed with CD it is highly important to follow a strict gluten free diet for the gut to recover.

Gluten containing grains were brought into the human diet over 10.000 years ago and since then various wheat varieties have been selected according to technological rather than alimentary reasons. Gluten is one of the food elements more abundantly used in the food industry due to its technological properties and taste (Day, Augustin, Batey, & Wrigley, 2006).

The interest and popularity for GF products has increased in the past years. In 2014, researchers from Canada investigated the number of persons who used GF products and found that 29% of Canadians are looking for GF products, of these only 7% did so for medical reasons. The remaining either perceived GF food to be a healthier option or had a family member requiring a GF diet (Agriculture and Agri-food Canada, 2014).

Gluten restrictions has important implications for nutrient adequacy, since staple western foods (e.g. breads, pastas, and cereals) are key nutrient sources for/of gluten in the western diet, especially when consuming whole grain foods (Helsedirektoratet, 2014).

Macronutrients and energy intake are often imbalanced both at the diagnosis of CD and with adherence to a GF diet(Al-Toma et al., 2019). Overweight in CD patients is becoming more prevalent with one study from Italy showing 40% of patients with CD being overweight at diagnosis (Zuccotti et al., 2013) and 13% in the obese range (Penagini et al., 2013; Wild, Robins, Burley, & Howdle, 2010).

The GF food market has expanded considerably, although there is limited knowledge about nutrient content in GF products and limited studies that compare nutritional quality in GF foods versus gluten containing products (Fry, Madden, & Fallaize, 2018).

2 BACKGROUND

2.1 Celiac disease

2.1.1 What is celiac disease?

Celiac disease (CD) is a chronic, multiorgan immune-mediated inflammatory disease triggered by gluten exposure in genetically affected individuals (Al-Bawardy et al., 2017). The disease affects the small bowl, and gives signs and symptoms such as diarrhea, abdominal pain, malabsorption, and weight loss (Al-Bawardy et al., 2017; Al-Toma et al., 2019).

The main goal in the treatment of CD is to relieve symptoms, heal the intestine, and reverse the consequences of malabsorption from the time before diagnosis. Further to enable the patient to maintain a healthful, nutritionally diverse GF diet (Al-Toma et al., 2019). Even small quantities of gluten may be harmful for individuals with CD. At time of diagnosis, some patients suffer from substantial weight loss, vitamin and mineral deficiencies, and anemia. Malabsorption of iron, folate, and calcium is common due to that these vitamins and minerals are absorbed in the proximal small bowel. When starting a GF diet most of these deficiencies resolves naturally, but in some cases individuals needs to take supplements for a short period (Al-Toma et al., 2019). For most patients following a GF diet it results in full clinical and histological remission (Hall, Rubin, & Charnock, 2009). Adherence to a GF diet is essential in order to achieve mucosal healing and to prevent complications of CD, therefor follow-up is needed to monitor adherence and response to diet (See, Kaukinen, Makharia, Gibson, & Murray, 2015)

2.1.2 Prevalence of celiac disease

Even though CD is a chronic autoimmune bowel disease triggered by gluten exposure in genetically predisposed individuals, there is a major difference in the number of genetical predisposed individuals and the actual prevalence of CD (Lindfors et al., 2019). It is estimated that 30-40% of the worldwide population are genetically disposed for CD, but only approximately 1% actually have the disease (Garcia-Mazcorro, Noratto, & Remes-Troche, 2018). Numbers from a study in Norwegian children indicate that the prevalence of CD in the Norwegian population is estimated to be 1.1%. This matches well with the prevalence of CD in Western Europe that is estimated to be 1% of the population (Dubé et al., 2005; Lund-Blix et al., 2019). CD affect all age groups, although more than 70% of new patients are diagnosed after the age of 20 years (Fasano et al., 2003). There is also an increase in individuals diagnosed with CD who have a first-degree family member affected with CD (Al-Bawardy et al., 2017; Book, Zone, & Neuhausen, 2003). In a systematic review concerning the global prevalence of CD they detected that biopsy-confirmed CD is 1.5 times more common in females than in males (Singh et al., 2018). The prevalence of CD and the number of new cases have risen over time, especially in non-western countries, and is considered a public health issue (Lindfors et al., 2019). The reason to the rise in prevalence is partly due to better diagnostic tools and from screening of at-risk individuals (Turner, 2018; Vujasinovic, Tepes, Volfand, & Rudolf, 2015), but also reflects a true increase in the prevalence of CD (Lindfors et al., 2019; Lohi et al., 2007). Changes in our environment including changes in dietary patterns are suggested to might have impact on rise in prevalence of CD (Lindfors, 2019, Lohi, 2012). Since lifestyle and diet are the major risk factors of non-communicable diseases (Mozaffarian, 2016), it is important to get knowledge about the nutrient content in GF food products, and to address if any specific factors in our diet is a trigger for CD.

2.1.3 **Risk factors for celiac disease**

The risk of developing CD is related to interactions between genetic, environmental and immune factors. Genetics play a major role in the development of CD (Al-Bawardy et al., 2017). In particular, the human leukocyte antigen (HLA) HLA-DQA1 and HLA-DQB1 genes have shown to be involved in the development of CD. These genes are involved in in the presentation of gluten peptides as antigens (Megiorni & Pizzuti, 2012; van Heel et al., 2007; Victorien & Cisca, 2008). Most CD patients (90-95%) carry HLA-DQ2 heterodimers encoded by DQA1*05 and DQB1*02 alleles which may be inherited together on the same chromosome or separately on the two homologous chromosomes. About 5-10% of CD patients carry either HLA-DQ8 heterodimers encoded by DQA1*03:02 or they carry HLA-DQ2, and a small number of patients (<1%) are not carrying these heterodimers, but express the other half of the DQ2 heterodimer (DQ7.5) (figure 1) (Abadie, Sollid, Barreiro, & Jabri, 2011; Megiorni & Pizzuti, 2012; Sollid et al., 1989). When having a first-degree relative with CD the risk of developing CD is increased (5-10%), the risk is lesser in second-degree relatives.

Only part of the familial aggregation observed for celiac disease seems to be explained by the HLA DQ2/DQ8 genes. Therefore, additional risk factors probably play a role (Stene et al., 2006). A Norwegian study from 2019 suggest that age of introduction to gluten, and gluten amount at age 18 months are risk factors for development of CD. In contrast to earlier beliefs, they found that introduction to gluten at >6 months of age was associated with a significantly higher risk of CD in comparison with introduction at 4 to 5.9 months of age. Concerning the amount of gluten consumed, they found that the amount of gluten ingested was higher in children who later developed CD compare with non-celiac-cases (Lund-Blix et al., 2019). Breastfeeding also seems to be related to development of CD. In a prospective birth cohort from 2013 researchers found that breastfeeding after 12 months of age was associated with an increased risk of CD (Størdal, White, & Eggesbø, 2013).

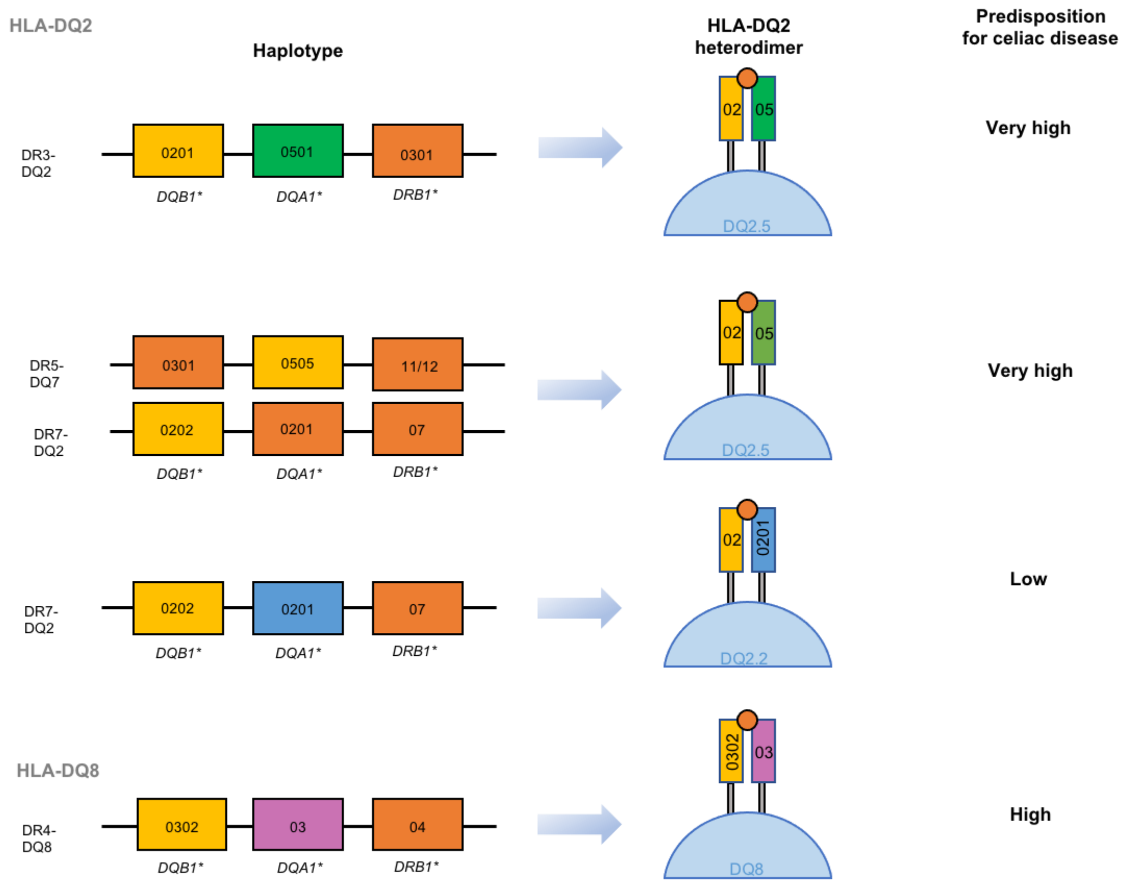


Figure 1 HLA associations in CD

Note:(Abadie et al., 2011)

Prospective studies have indicated that there is a higher frequency of infections in children before diagnosis of CD. There is limited research on infections as risk factor for development of CD. In 2006, for the first time, researchers found results that indicate that a high commonness of rotavirus infections could increase the risk of CD autoimmunity in childhood, in genetically predisposed children (Stene et al., 2006). Further, a Norwegian research group has investigated enterovirus as a trigger of CD. They found that a higher prevalence of enterovirus, during early childhood was associated with subsequent CD (Kahrs et al., 2019). In the search for environmental determinants influencing the onset and development of CD, the intestinal microbiota has been recognized as an attainable causal factor. The microbiota in infancy is strongly affected by systemic antibiotics and is less resilient to environmental exposures compared to later in life. In a nationwide study of children in Denmark and Norway, researchers found that exposure to systemic antibiotics in the first year of life was associated with later diagnosis of CD. Their findings indicate that exposure to systemic antibiotics in childhood could be a risk factor for CD (Dydensborg Sander et al., 2019).

To summarize, much is known about factors that may trigger development of CD, and as well as if any dietary components in a GF diet could affect development of non-communicable diseases. It is important to investigate dietary risk factors due to the fact that a GF diet is the medicine for persons with CD.

2.1.4 **High-risk groups**

Some groups have especially high risk of developing CD, and in some cases it can be reasonable to screen these groups for CD (Ludvigsson et al., 2015). First-degree relatives are in high risk of developing CD. The prevalence is significantly higher in monozygotic twins and in families with multiple persons affected (Greco et al., 2002). Type 1 diabetes (T1D) is one of the most common autoimmune diseases in patients with CD. Between 2 and 12% of all T1D patients have CD. The relative risk for future T1D in patients with CD is predicted at 2.4, meaning that the likelihood for developing T1D for CD patients is 2.4 times higher than for the average population. The relative risk for white persons with HLA-DQ2+ to develop T1D is almost identical (Fasano et al., 2003; Hansen et al., 2006; Ludvigsson, Ludvigsson, Ekbom, & Montgomery, 2006; Poulain, Johanet, Delcroix, Lévy-Marchal, & Tubiana-Rufi, 2007; Skovbjerg, Tarnow, Locht, & Parving, 2005; van Autreve et al., 2004).

Due to malabsorption, ongoing inflammation and occult bleeding CD may cause iron-deficiency anemia (Fine, 1996; Ransford, Hayes, Palmer, & Hall, 2002). CD is also more common in patients with iron-deficiency anemia and gastrointestinal symptoms and therefore patients with iron-deficiency is in the high-risk group (Ford et al., 2009). People with Downs syndrome is expected to be a high-risk group for development of CD. There seems to be common pathogenic factors for the two diseases, such as the presence of common histocompatibility antigens that could be involved in the immune system (Castro et al., 1993; Failla et al., 1996). In a study from 2001 researchers investigated the prevalence of CD in people with Downs syndrome and found that the minimum prevalence rate of CD was 6% (Carnicer et al., 2001). In other previous studies, the prevalence ranged from 3% to 19% (Carlsson et al., 1998; Castro et al., 1993; Failla et al., 1996; Gale, Wimalaratna, Brotodiharjo, & Duggan, 1997; George et al., 1996; Jansson & Johansson, 1995; Storm, 1990).

2.1.5 Diagnosis

The European Society for the Study of Coeliac Disease address active case-finding, such as serological testing for CD among individuals with only subtle or atypical symptoms, and in risk groups, as the favored strategy to increase detection of CD (Al-Toma et al., 2019). This strategy is based on experiences from Finland, where testing and increased awareness to the condition have made efficient diagnosis of CD (Virta, Kaukinen, & Collin, 2009). There are several different tests that can contribute to confirm CD as diagnose. The diagnosis of CD depend on a combination of clinical history, serological and histopathological data (Al-Toma et al., 2019). Serological test for immunoglobulin Anti Endomysial antibodies and immunoglobulin anti-transglutaminase 2, together with endoscopic biopsy of the small bowl is used to diagnose CD (table 1). Both these tests are highly sensitive (96% and 93%) and highly specific (97% and 96%) (Schuppan & Zimmer, 2013). The human leukocyte antigen (HLA) typing, if available, can be considered as the first line test for first-degree relatives; no further diagnostic workup is needed of those who are negative for HLA-DQ2/8 (figure 2) (Al-Toma et al., 2019). Concerning children as potential CD patients there are specific guidelines for diagnosis (Husby et al., 2020). In children, symptoms often present in other ways than in adults. Symptoms such as failure to thrive, diarrhea, muscle wasting, poor appetite and abdominal distension occurs frequently (Fasano, 2005). The European Society Paediatric Gastroenterology, Hepatology and Nutrition Guidelines for Diagnosing Coeliac Disease (ESPGHAN) were updated in January 2020 and gives the latest recommendations for diagnosing children with CD. They recommend that the first serological test should be a combination of total immunoglobulin A and immunoglobulin A class antibodies against transglutaminase 2, and that this is the most accurate test combination. Further, they state that biopsy is not needed in children with high serum immunoglobulin A class antibody concentrations against transglutaminase 2 values (> 10 times the upper limit of normal) and positive endomysial antibodies in a second serum sample. For children with positive immunoglobulin A class antibodies against transglutaminase 2 but lower titers (<10 times upper limit of normal) should go through biopsies to minimize the risk of false positive diagnosis (Husby et al., 2020).

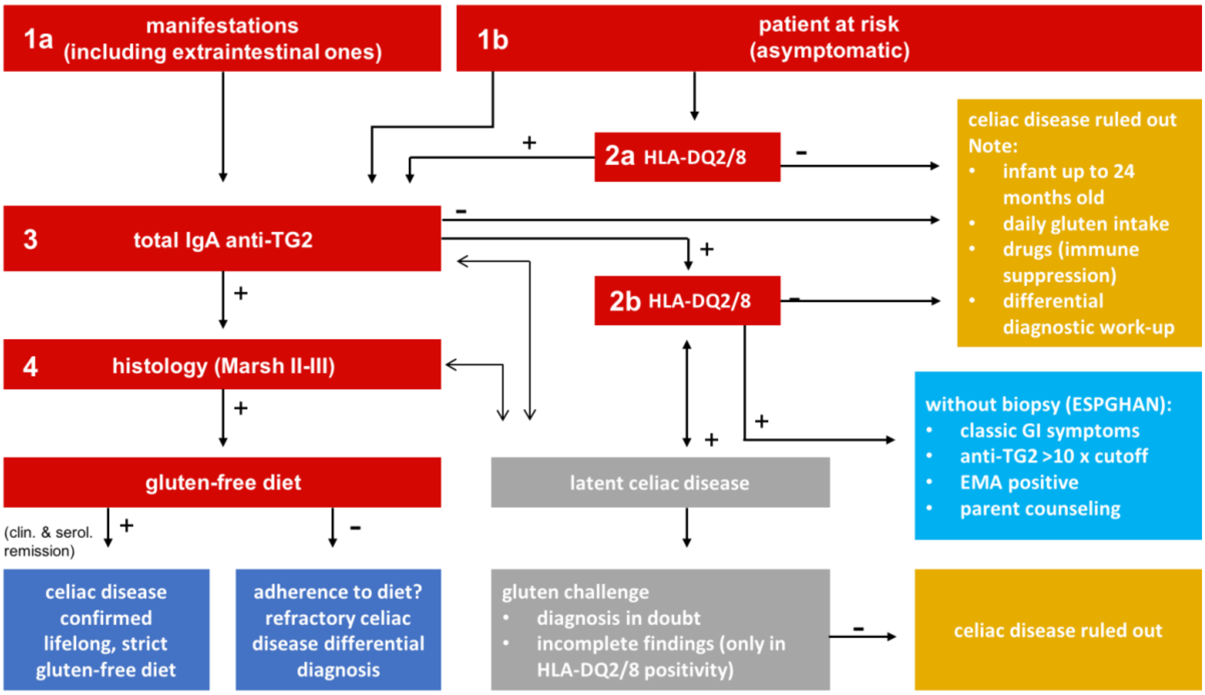


Figure 2 Decision flowchart for the diagnostic evaluation of celiac disease

Note: The diagnostic features that are confirmatory of celiac disease are shown in red, while those that rule it out are shown in yellow. In latent celiac disease, it is important to demonstrate HLADQ2/8 positivity and to confirm or exclude the diagnosis both serologically and histologically while the patient continues to consume gluten. The ESPGHAN criteria allows diagnosis of celiac disease in children without duodenal biopsy. In rare cases (e.g., IgA deficiency), the classic antibodies or HLA-DQ2/8 may not be detectable in a patient with celiac disease. It follows that, whenever the clinical manifestations put celiac disease in the differential diagnosis, biopsy is indicated. EMA = anti-endomysium antibodies; GI= gastrointestinal tract (Schuppan & Zimmer, 2013).

2.2 Other gluten related diseases

In addition to CD, there are two more conditions that require a GF diet, NCGS and WA. NCGS is defined as a state of gastrointestinal and extra-intestinal symptoms that improve with a GF diet. The prevalence of NCGS have been reported to be from 0.6% to 6% (Skodje et al., 2019). In contrast to the diagnosis of both CD and WA there are no serological test that can confirm NCGS. The diagnosis of NCGS is based on clinical reactions to a GF diet and results of a gluten challenge preferably for minimum six weeks. If the patients fulfill the response criteria, that is to have more than 30% reduction of one to three main symptoms for at least 50% of the observation time, the patient is likely to be diagnosed with NCGS If the patient is a non-responder to GF diet and gluten challenge the patient should be investigated for other possible causes of irritable bowel syndrome like symptoms, this could be intolerance to fermentable oligosaccharides, disaccharides, monosaccharides and polyols (FODMAPs) or small bowel bacterial overgrowth. The treatment of NCGS is similar to the treatment of CD, and is a GF diet (Catassi et al., 2015).

WA has in common with CD an oppositional reaction to proteins from wheat in which the immune system is involved. WA is mediated by antibodies from the immunoglobulin E family and it is mainly induced by proteins found in wheat and not necessarily in other grains such as barley or rye (Pourpak et al., 2005). WA presents various clinical manifestation that have a differential incidence depending on the age group (Keet, Matsui, Mudd, Paterakis, & Wood, 2008; Nilsson et al., 2015). The diagnosis of WA depends on a detailed clinical history, physical examination and selection of the suitable tests. The first test include measurement of specific IgE to wheat extract and wheat allergens in blood serum and skin prick test. In the incident of allergy to wheat due to ingestion in pediatric and adult patients, the clinical history and results of specific test is seen together, and an oral food challenge can be performed. Even though oral food challenges are described as safe, they must be carried out with carefulness by medical personnel, since anaphylactic reactions may occur. The only available treatment for IgE-mediated WA is a GF diet (Sicherer & Sampson, 2018).

Table 1 Characteristics of gluten related disorders

	CD	**WA**	**NCGS**
Prevalence	0,5-1,7%	0,5-9% in children	No population studies
Pathogenesis	Autoimmune	IgE mediated response	non-specific immune response
Serological markers	IgG anti-EMA, IgA anti-tTG, IgG anti-DGP, IgA Anti-gliadin	Specific IgE antibodies against wheat and gliadin	IgA/IgG anti-gliadin in 50% cases
Duodenal villi atrophy	Present	Might be present or absent	Absent

Notes: CD = Celiac disease, WA = Wheat allergy, NCGS = Non-celiac Gluten-sensitivity, IgG anti-EMA = Immunoglobulin G Anti-endomysial antibody, IgA anti-tTG= Immunoglobulin A anti-transglutaminase, IgG anti-DGP = Immunoglobulin G anti-deaminated gliadin protein epitopes, IgA Anti-gliadin = Immunoglobulin A Anti-gliadin, IgE = Immunoglobulin E.

2.3 Gluten

2.3.1 What is gluten?

Gluten is a general term used to describe a mixture of wheat storage proteins (Gliadin and Glutenin) (figure 4) (Saturni, Ferretti, & Bacchetti, 2010). Gluten contains hundreds of protein components, and presents either as monomers, or connected by interchain disulphide bonds as oligo- and polymers. Gluten proteins are defined by a high content of the amino acids: glutamine and proline, and by low content of amino acids with charged side groups (figure 3). Gluten proteins can be detached into two major fractions according to their solubility in aqueous alcohols: the soluble gliadins and the insoluble glutenins. Both parts consist of several, partially closely related protein components characterized by high glutamine and proline contents (Wieser, 2007). Gluten proteins are present in wheat, rye and barley (Stevenson, Phillips, O'Sullivan, & Walton, 2012).

Gluten is an important ingredient of foods made from cereal grains or their derivates, providing a matrix of viscoelasticity, which, if removed, can negatively affect the structural integrity and structure of foods such as bread and pasta. No substitute raw material or additives have been found to have the same qualities of gluten and therefore products manufactured in place of traditional gluten containing foods require the utilization of a combination of GF flours, hydrocolloids, emulsifiers, stabilizers and enzymes (Fry et al., 2018).

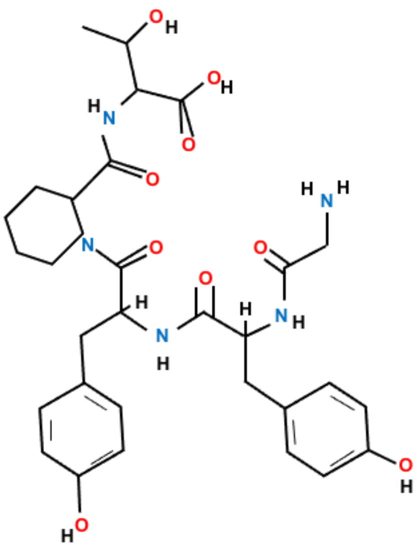


Figure 3 Structure of gluten (Gluten Exorphin A5)

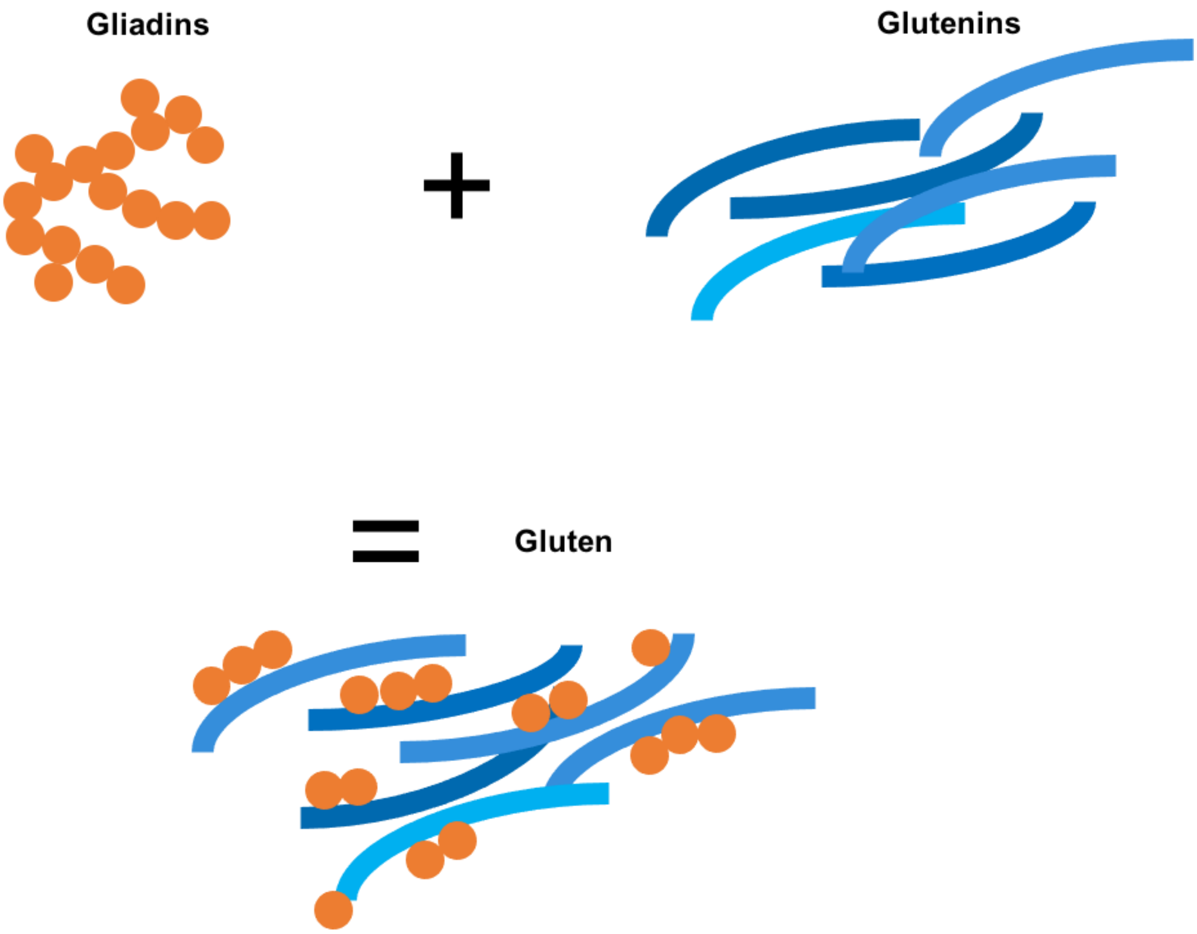


Figure 4 Illustration of gluten protein

2.3.2 Gluten free food

There are several sorts of food that is naturally GF, such as milk, butter, cheese, fruit and vegetables in all forms, fresh meats, fish, chicken, eggs, beans, seeds and nuts. Gluten is mostly found in bread, cereals, and pasta. However, sometimes it is also found in seasoning, sauces, marinades, soy sauce, soups, salad dressing and even in some sorts of flavored rice (Niewinski, 2008). The popularity of GF products has increased in the general population, the increase in popularity is due to a public perception that a GF diet lead to improved health (Newberry, McKnight, Sarav, & Pickett-Blakely, 2017). In the Nielsen global health and wellness study (2015), 23% reported that they avoided products that contained gluten, and 21% said that it was important for them to buy products free from gluten. The survey divided the participants into age groups, and in the millennial group (age 21-34), 29% were willing to pay extra for GF products. Nielsen suggest that the millennial group are leaders in the GF movement (The Nielson Company, 2015). When diagnosed with a gluten-related disease that require a GF diet as treatment it is important that patients get educated to avoid gluten containing cereals including wheat, barley and rye. It is also important to be aware of gluten-contamination. Further, it is important that patients requiring a GF diet to be educated in reading labels to ensure that each product is GF (Al-Toma et al., 2019; Niewinski, 2008).

The safe level of gluten for CD patients is regarded to be <20 parts per million (ppm) (Al-Toma et al., 2019). According to Codex Alimentarius Commission of the World Health Organization (WHO) issued guideline for gluten content of processed food from 2008 and European Commission law EC41/2009 products has to contain <20 ppm of gluten to be labeled as "gluten free". Rules and laws for labeling of GF products differ around the world. In Norway labelling of food products are regulated by the food information regulations law (Norwegian: matinformasjonsforskriften) (Matinformasjonsforskriften, 2015). The purpose of this law is to give general regulations on labeling of food products. This law regulates how products especially produced for persons with gluten-related diseases should be labelled. The regulations declare that some products should have the opportunity to be labelled with specifications such as absence of gluten ("gluten free"/Norwegian: "Glutenfri"), or reduced absence of gluten («Very low content of gluten»/Norwegian: «svært lavt gluteninnhold»). The following products are included in the regulation: products that are manufactured, prepared or processed in order to reduce gluten content in one or several gluten containing ingredients, or to exchange the gluten containing ingredients with other ingredients that is naturally free from gluten. These sorts of products should also give information that the product is especially composed for persons with gluten intolerance. Further, food sold without being prepacked such as in restaurants and bakeries, also have to be labelled. Ingredients or technical auxiliaries used in the manufacturing or preparation of a food product that could cause allergic reactions has to be labelled (Matinformasjonsforskriften, 2015).

2.3.3 Pseudo-cereals

Pseudo-cereals are plants that are similar to grains, but they are not grasses or even monocotyledons and can therefore not be classified as cereals, thereby called pseudo-cereals. Examples of pseudo-cereals are buckwheat, quinoa, and amaranth, which all are GF and could be part of a GF diet (Rosentrater & Evers, 2018, pp. 68-69). The importance of pseudo-cereals is now increasing as they have been better characterized demonstrating that they are a good source of macronutrients such as carbohydrates and proteins, but also of vitamins and minerals (Saturni et al., 2010). These plants have particularly a high fiber content, with a range from 6.7-10 g/100 g. Compared to other plant foods such as fruit and nuts, the content of fiber is higher in pseudo-cereals (table 2). Among pseudo-cereals, buckwheat has the highest fiber content. Further, the lipid content in pseudo-cereals could be considered high when compared with other cereals, but they are characterized by a higher content of unsaturated fatty acids (Saturni et al., 2010), and particularly linolenic acid (Adeyeye & Ajewole, 1992; Yánez, Zacarías, Granger, Vásquez, & Estévez, 1994). Pseudo-cereals have different qualities and are therefore used in different ways. All three can be used in bread in combination with other flours and are often used to make bread with higher digestion value. Amaranth can be used both as grain and flour, when used as grain it is used to make popped cereals, and amaranth flour is used in baking product as a flavoring and have a nutty flavor. Quinoa is also used as flour in bread, porridge and similar products, and in recent years, it has been promoted as a "health food". Buckwheat grain is most used as a nutritive supplement for stews, and buckwheat flour is used in noodle making in Japan.

Table 2 Fiber content in cereals and pseudo-cereals

	Fiber (g/100g)
Cereals	
Oat	10.3
Wheat	9.5
Barley	9.2
Spelt	6.8

Corn	7.3
Rice	2.8
Teff	8.0
Pseudo-cereals	
Buckwheat	10.0
Quinoa	7.0
Amaranth	6.7
Fruit and vegetable	0.5-5.0
Nuts	4.0-12.0
Pulses	5.0-18.0

(Saturni et al., 2010)

2.4 Challenges with a gluten free diet

Macronutrients and energy intake is usually not balanced correctly in people with CD at diagnose, this is also an issue for people on a GF diet (Caruso, Pallone, Stasi, Romeo, & Monteleone, 2013; Penagini et al., 2013; Saturni et al., 2010; Shepherd & Gibson, 2013; Zuccotti et al., 2013). Macronutrients are the nutrients that give us energy. It can be divided into fat (9 calories per gram), carbohydrate (4 calories per gram), and protein (4 calories per gram). The health authorities gives recommendations on how much energy each macronutrient should provide us with (table 3) (Norden, 2014).

Table 3 Recommended intake of macronutrients.

Macronutrients	
Total fat	25-40 E%
Saturated fat	<10 E%
cis-monounsaturated fatty acids	10-20 E%
cis-polyunsaturated fatty acids	5-10 E%
Carbohydrate	45-60 E%
Protein	10-20 E%
Alcohol	<5 E%

*Numbers are given in energy percentage (E%)

(Norden, 2014).

2.4.1 Nutrient content in gluten free products

Studies from abroad states that GF products usually have a greater carbohydrate and lipid content than their gluten containing counterparts, and the GF products is particularly higher in saturated fatty acids (Penagini et al., 2013). It is well known that the intake of monounsaturated and polyunsaturated fats should be preferred as they are associated with reduced cardiovascular disease (CVD) risk (Mozaffarian, Micha, & Wallace, 2010). Total fat intake should represent about 25-40% or less of total calorie intake, the intake of monounsaturated and polyunsaturated fat should be preferred, and should make up a minimum of 2/3 of the total fat intake (Norden, 2014).

In a GF diet the main dietary source of protein is animal foods such as meat, eggs, fish, milk and dairy products. Plant foods which are useful sources of protein include legumes, seeds, nuts and GF cereals (Abdel-Aal & Hucl, 2002; Gorinstein et al., 2002).

The average Norwegian consumer consumes 82 kg of grains annually, and carbohydrates represents 45% of the daily food intake. Half of our intake of dietary fiber comes from grains (Helsedirektoratet., 2019). Consumption of dietary fiber provides many health benefits. A large intake of dietary fiber reduces the risk of developing a great number of diseases. It has been proved to reduce the risk of developing certain gastrointestinal disorders (Petruzziello, Iacopini, Bulajic, Shah, & Costamagna, 2006), obesity (Lairon et al., 2005), diabetes (Montonen, Knekt, Jarvinen, Aromaa, & Reunanen, 2003), stroke (Steffen et al., 2003), hypertension (Whelton et al., 2005) and coronary heart disease (Liu et al., 1999). Unfortunately, dietary intake of fiber in the general adult population in Norway is lower than advises from the Norwegian health authorities. The average intake of dietary fiber should be 25 grams per day for women and 35 grams per day for men (Helsedirektoratet, 2011). However, numbers from national dietary surveys tells us that the average intake is 22 grams per day for women and 26 grams per day for men (Totland, Helsedirektoratet, Universitetet i, & Mattilsynet, 2012). The sub-optimal intake of dietary fiber is a result of insufficient intake of whole-grain foods, vegetables, fruits, legumes and nuts (Helsedirektoratet, 2014). The definitions of dietary fiber vary internationally, however The European Food Safety Authority (EFSA) define dietary fiber as:

> Non-digestible carbohydrates plus lignin including non-starch polysaccharides (NSP) – cellulose, hemicelluloses, pectins, hydrocolloids (i.e. gums mucilages, β-glucans),

resistant oligosaccharides – fructo-oligosaccharides (FOS), galacto-oligosaccharides (GOS), other resistant oligosaccharides, resistant starch – consisting of physically enclosed starch, some types of raw starch granules, retrograded amylase, chemically and/or physically modified starches, and lignin associated with the dietary fibre polysaccharides (European Food Safety Authority, 2010).

2.4.1 Health effects of a gluten-free diet

In recent years, there has been several studies on how our gut microbiota can affect obesity related diseases and have a part in our metabolism. Short-chain fatty acids are gut microbial metabolites derived from fermentation of dietary fiber that have important metabolic functions. These metabolites might prevent obesity by boosting energy expenditure, increase anorexic hormone production and improve appetite regulation. Further, short-chain fatty acids are suggested to affect metabolic regulation, included glycemic regulation and lipid metabolism, this could affect the risk of developing non-communicable diseases (Canfora, Meex, Venema, & Blaak, 2019).

A GF diet is often characterized by a lower intake of dietary fiber compared to regular diet containing gluten (Penagini et al., 2013). GF products are normally made with starches and or refined flours characterized by a low content of fiber. During the production process, in particular the refined process, the outer layer of the grains is taken out leaving the starchy inner part. As is known, the outer layer containing the most of the fiber so the refined process is related with a decrease of fiber content (Penagini et al., 2013).

It is limited research and knowledge about how a GF diet affect our health. It is therefore unknown if persons with CD could have increased risk for development of metabolic diseases like type 2 diabetes (T2D) and CVD. Even though some studies have found that the prevalence of CD is higher among individuals with T2D than in the rest of the population (Kizilgul et al., 2017), other studies have found that individuals with CD have lower or comparable prevalence of T2D and metabolic syndrome (Kabbani et al., 2013; Kylokas et al., 2016). Santoro et al. (2017) made a systematic review and found that persons with CD seems to have increased risk for development of both T2D and CVD (Santoro et al., 2017). Some studies indicate that a GF diet gives reduced risk of T2D, because of that the intestinal permeability gets reduced, and that one finds reduction in inflammatory markers in the blood and reduced weight/obesity (Haupt-Jorgensen, Holm, Josefsen, & Buschard, 2018). The prevalence of T2D and CVD among persons with CD in Norway is unknown. As mentioned, there is limited knowledge about the diet of persons with CD, and the nutrient content in a GF diet. It is uncertain if these effects would be current regardless of type of GF diet, included with a low consumption of dietary fiber, and when a GF diet leads to increased body mass index.

Increased energy density, lack of fiber and lower nutrient density in the GF diet may lead to difficulties concerning nutrient inadequacy and weight management in long-term. CD patients are often diagnosed with iron deficiency and anemia, inadequacy of B vitamins such as folate, zinc and calcium, and low mineral density, therefore this group is especially vulnerable to get even more nutrient deficiencies (Silvester & Rashid, 2007).

There is no available dietary survey that investigate the diet of persons following a GF diet in Norway. Concerning the general population, we have reliable information about their diet. In "Norkost 3", a national dietary survey that investigate the actual intake of food and nutrients among adults in Norway the average intake of foods and nutrients is presented. The results from this survey indicate that only a quarter of the participants had an adequate intake of vegetables, fruit, berries and wholegrains, and one quarter satisfied the recommendations on energy amount from saturated- and polyunsaturated fatty acids, carbohydrate and dietary fiber. The average amount of energy from saturated fatty acids were higher than recommended and the amount of energy from carbohydrates and dietary fiber were lower than recommended (Totland et al., 2012). This indicates that when planning an optimal GF diet, it cannot be compared to the average intake in the population since the majority of the Norwegian population do not meet the dietary recommendations. Since there is a lack of dietary assessments on persons following a GF diet in Norway we do not know if the result would be similar to the once from Norkost 3. Studies from abroad confirms that the amount of fiber in GF products is lower than recommended (Fry et al., 2018; Jamieson, Weir, & Gougeon, 2018), but we do not know if that is the case in Norway. Numbers from Norkost 3 shows that in the average adult population 53% of dietary fiber consumption comes from bread and grain-products (Totland et al., 2012).

As mentioned, there is limited available research and knowledge about the GF diet, what it contains and how it affects our health. We do not know if a GF diet increase the risk of non-communicable diseases like T2D and CVD. To get more knowledge about this it is highly relevant to investigate the nutrient composition of GF products. Further to make more and healthier GF food products it is necessary to collect data on nutrients in packed GF products that are available in Norwegian grocery stores.

2.5 Financial support for persons with celiac disease

Higher costs and limited availability of GF products are familiar challenges for persons with CD. Most GF products are 2-3 times more expensive than gluten containing food, and worldwide the availability of GF foods is limited, especially in less developed areas. In some countries, GF replacement products are only available by prescription. However in developed countries the assortment is rising due to the fact that GF products now appeal to a broader group of people who eat a GF diet for various reasons (Kang, Kang, Green, Gwee, & Ho, 2013; Rubio-Tapia, Ludvigsson, Brantner, Murray, & Everhart, 2012; West, Fleming, Tata, Card, & Crooks, 2014). There is no research that compare price of GF food products to comparable gluten containing products in Norway, and since price seems to be an important factor for the choice of food (French, 2003), it is important to get more knowledge about the cost of a GF diet in Norway.

According to the National Insurance Act (Norwegian: "Folketrygdloven") chapter six about basic and auxiliary benefits, all Norwegian citizens that are diagnosed with CD should have the opportunity to apply for a monthly financial support from the government. The financial support should cover extra expenses due to higher cost for GF food products, and makes it possible for people with CD to buy replacement products that are GF and more expensive (Folketrygdloven, 1997). During the recent years the amount of the financial support has been discussed several times. In 2018 the government requested an assessment of extra expenses for persons with CD. The report evaluated extra cost based on a reference budget that allows a soberly life. The nutrient assessment is based on average energy intake for an adult with an average activity level. In the report they concluded that the extra costs was 655 Norwegian kroner per month compared to a diet with gluten containing foods (Forbruksforskningsinstituttet SIFO, 2018). This resulted in a reduction in the financial support. From 2018 to 2020 the financial support has been reduced from a yearly amount of 24252 Norwegian kroner to 8232 Norwegian kroner (NAV, 2020). There is no report that estimates cost of a GF diet based on the best available alternative and in Norway, meaning that there is a lack of knowledge on the extra expenses in a GF diet if choosing products that meet dietary recommendations.

3 AIM

This master thesis is part of a larger research project with the overall aim to investigate the health effects of a GF diet. The aim of this master thesis aims to characterize the nutrient content in GF products in the Norwegian grocery stores.

The following research questions will be answered in this master thesis:

- Are GF products less nutritious concerning macronutrients than comparable gluten containing benchmark products?
- Are GF products more expensive than gluten containing products?
- Is it possible to reach the national dietary recommendations for macronutrients with a gluten free diet?

4 MATERIALS & METHODS

To be able to answer the research question a database was developed (attachment 1). The database contains nutrient content and price of GF and gluten containing products from the Norwegian grocery stores. Nutrient content per 100 gram in GF products was compared to similar gluten containing products.

4.1 Development of database with gluten free products

Overall, five grocery stores in Oslo & Akershus (now named Viken): Meny Bryn, Meny Sandvika, Jacobs Utvalgte Majorstuen, Coop Obs Haugenstua and Rema 1000 kanalveien, and three web-based grocery stores: Kolonial.no, Meny.no, and Allergikost.no were visited during September and October 2019. The stores were chosen based on location and assortment of GF products. From the five grocery stores there were four different once to ensure that we found all available GF products on the Norwegian market. The collection started in the web-based grocery stores, and supplemental collection were done in grocery stores (figure 5).

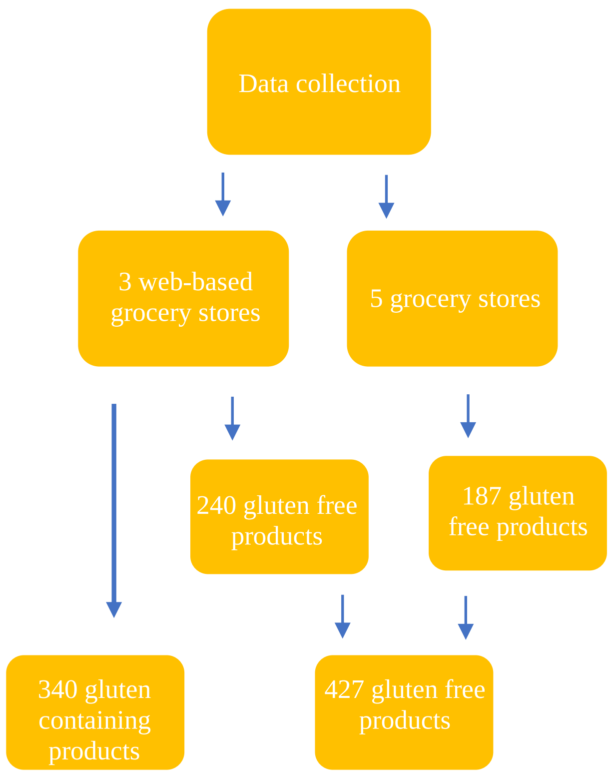


Figure 5 Model of data collection in web-based stores and grocery stores

The collection of the gluten containing counterparts was done online in the same web-based stores, in the same period. Items were considered to be GF if the product packaging or description included a declaration of GF content. Products without nutrient labels and products that were naturally GF (e.g., rice, meat, fruits, vegetables) were excluded. The collection started with products categorized as free from gluten by the grocery store. Then all product categories were assessed to ensure that all products marked as GF were collected. If the exact same product were found in several web-based grocery stores the cheapest price were chosen. When a GF product was found information about price, amount, energy content (kcal), fat, saturated fat, protein, carbohydrates, sugar, fiber, salt and nutrition claims were collected. If available, content of monounsaturated fat, polyunsaturated fat, iron, iodine, and folic acid were collected as well. When new GF products were found in stores during supplemental collection, it was taken pictures of the products front page, nutrient label, and price label, see figure 6. The pictures were stored in a phone until they were computed into the database. To ensure that all products from the grocery stores were included the shelves were assessed systematically from top to bottom.

Figure 6. Pictures from data collection in grocery stores. Picture of front page, nutrient label and price label.

For every GF product a comparable gluten containing product were collected and recorded. When selecting comparable gluten containing products, this list of criteria were followed: (1) the product should be as similar in purpose as possible and match the product description for the GF product, (2) the products should meet the dietary guidelines or have “nøkkelhull” symbol, (3) for bread, only breads with the Norwegian bread scale were chosen, preferably the once with 4/4 or 3/4 squares on the bread scale, (4) when there was several options a product not sampled earlier were chosen to increase representativeness of the gluten containing products. In cases of only one available option that were similar to the GF product, the gluten containing product had to be matched with several different GF products. Eleven products had amount declaration in ml and were converted into grams.

4.2 Data entry

All GF and gluten containing products were recorded into excel. All products were given a product and category number and were thereafter sorted into eleven different categories (table 4). The categories are chosen based on intended use, regular food-categories from web-based grocery stores, and sales numbers for GF products in Norway from ACNielsen Norway.

Table 4 Description of the eleven different categories from the database.

Category	Description
Cereals	Includes all oat product, muesli, granola and different types of breakfast flakes.
Bread	Includes all sorts of bread, ciabatta, baguettes, paninis, rolls and sandwich bread.
Pasta	Includes all sorts of pasta, spaghetti, macaroni, fusilli, pasta screws, penne, lasagna plates and tagliatelle.
Cake	Includes different kinds of sweet cakes.
Snacks	Includes cookies, biscuits, a broad spectrum of energy bars, crackers and chocolate.
Flour mixes	Includes mixes of clean flours without added seasonings and sugar.
Baking mixes	Includes flour products with additives like sugar, yeast and different seasonings. Includes mix for waffle, buns, cakes, cookies and similar products.
Clean flour	Includes all clean flours available on the Norwegian market.
Dinner products	Includes all products that is used for dinner, except pizza and pasta.

Crispbread	Includes all sorts of crispbread
Pizza	Includes frozen pizza and pizza crusts.

4.3 Data analysis

In this study unique, non-duplicate GF products were treated as “cases”, while gluten containing counterparts were treated as “controls”. This design is similar to a case-control study in observational study designs. All data are reported in median nutrient content per 100 grams of GF versus gluten containing products and compared using Wilcoxon rank sum test due to non-normality. All analyses are done in SPSS Statistics (version 26.0.0.0).

The variables were checked for normality by the Kolmogorov-Smirnov test, and, in light of the results, the data were expressed as median (percentile 25- percentile 75) for all variables. Wilcoxon signed rank test is used to compare nutrient content in GF products versus gluten containing products. This test is often used to test whether the difference between the medians of the two paired variables is zero. The null assumption is that, the two medians are equal (Bowers, 2020, pp. 241-243). Non-parametric tests are often used when the observation contain skewness, or when the sample has few observations. This test handles extreme-values good, and takes into account that the distribution is not normal (Aalen & Frigessi, 2018, p. 197). The level of significance was set at $p < 0.05$ for all analyses. The *p*-value measures the strength of the evidence against the null hypothesis. The smaller the *p*-value, the stronger the evidence. The less likely is that the outcome you got occurred by chance, that is, it was due to sampling (Bowers, 2020, pp. 241-243).

4.4 Reference diets

To estimate if it is possible to consume enough of each micronutrient and fiber, two different reference diets were developed. One reference diet is based on recommendations on wholegrains and fiber (attachment 4), and the other reference diet is based on a nationwide diet survey named Norkost 3 (attachment 2 and 3).

The Norwegian health directorate have given twelve concrete dietary advices. One of them is about dietary fiber, were they recommend a daily intake of dietary fiber of 25 grams for women and 35 grams for men (Helsedirektoratet, 2011). Estimated differences in intake of fiber from wholegrain products in a GF diet and a regular diet with gluten containing products has been performed. The dietary guidelines includes examples of how to manage to eat enough whole grains, which are used to compare fiber content in three different alternatives for wholegrain consumption (Helsedirektoratet, 2011). Alternative 1) contains four slices of bread preferably with wholegrain. Alternative 2) contains a plate of wholegrain cereals and two slices of bread. Alternative 3) contains a plate of oatmeal and a portion of wholegrain pasta or wholegrain rice. Norkost 3 is a nationwide diet survey among men and women in Norway in the age 18-70 years. The survey is from 2010-2011. The survey provides numbers of different foods the population consume, given in edible amount in gram per day in average. It also provides numbers on intake of energy and macronutrients (Totland et al., 2012). All these numbers are in the present study used to investigate how energy and macronutrient intake changes when gluten containing foods is changed with GF foods. The three different alternatives are based on products from the database with both GF and gluten containing products, the alternatives are taken from each category and are based on 1) products high in fiber and protein 2) products low in fiber and protein, and 3) lowest price. The choice of products to use in the estimation were found by sorting the product category after highest fiber content and protein content, lowest fiber and protein content and lowest price. If the products with the highest or lowest values missed other values the second product in the range were chosen.

RESULTS

4.5 Sample description

The database consists of 427 unique GF products and 340 comparable gluten containing items. All items are divided into 10 different categories. The database presents quantitative information about macronutrients and price of GF products.

4.6 Results by categories

The nutritional values for all products together are presented in table 5. The amount of saturated fat (*p*=0,001), carbohydrates (*p*= <0,01) and salt (*p*= <0,01) are significantly higher in the GF products compared with gluten containing products. For fiber (*p*= <0,01) and protein (*p*= <0,01) the amount is significantly lower in GF products for all products together. There were no significant differences in the amount of sugar and total fat between the two groups.

Table 5 Nutrient content in total GF and gluten containing products

Nutrient per 100 g	**Gluten free, Median (IQR) (n=427)**	**Gluten containing, median (IQR) (n=340)**	**P-Value**
Calories (kcal)	357 (272 – 410)	348 (270 – 389)	0.004
Fat (g)	5.4 (1.9 – 14.0)	5.4 (2.2 – 12.0)	0.333
Saturated fat (g)	1.0 (0.5 – 3.7)	0.9 (0.4 – 2.8)	**0.001**
Carbohydrate (g)	61 (44 – 74)	58 (42 – 65)	**<0.01**
Fiber (g)	4.4 (2.2 – 7.5)	5.9 (3.0 – 8.8)	**<0.01**
Sugar (g)	3.5 (1.0 – 14.0)	3.3 (2.0-11.0)	0.564
Protein (g)	5.8 (3.3 – 8.5)	9.5 (7.3-12.0)	**<0.01**
Salt (g)	0.7 (0.2 – 1.2)	0.7 (0.1 – 1.0)	**<0.01**

Notes: IQR = Interquartile range.

P-value is considered significant when it is 0.05 or lower.

4.6.1 Bread, crispbread and cereals.

The results for nutritional values for bread, crispbread and cereals are presented in table 6. Bread is a category that consists of 66 GF and 57 gluten containing products. This category contains all sorts of bread, ciabatta, baguettes, paninis, rolls and sandwich bread. The category crispbread consists of 25 GF- and 23 gluten containing products, and this category only consists of crispbread. The category for cereals has 61 GF and 45 gluten containing products, and the category consists of all oat products, muesli, granola and different types of breakfast flakes. GF bread had 44% more saturated fat than comparable gluten containing breads (p=0,006). Both GF crispbread (p=0,006) and cereals (p= <0,01) contained significantly more carbohydrates then comparable benchmark product, but for bread it contained 5% less carbohydrates (p=0,048) than benchmark products. The fiber content is lower in GF products compared to gluten containing products for all three categories but only significantly lower in bread (p=0,001) and cereals (p=0,006). For all three categories the content of protein was significantly lower in GF products (bread: p=<0,01, crispbread: p=0,009, cereals: p=<0,001). The content of salt was higher in gf cereals compared to gluten containing cereals (p=0,005).

4.6.2 Flour mix, baking mix and clean flours

In the database, flour-based products are sorted into three categories: flour mix, baking mix and clean flours, and the results for these categories is presented in table 7. Flour mixes consists of 12 GF- and 7 gluten containing products. This category includes mixes of clean flours without added seasonings and sugar. Baking mixes consist of 25 GF- and 14 gluten containing products. This category includes flour products with additives like sugar, yeast and different seasonings, that includes mix for waffle, buns, cakes, cookies and similar products. Clean flours consist of 16 GF- and 16 gluten containing products. This category includes only clean flours, like for example corn flour, potato flour and rice flour. Both GF flour mix (p=0,004) and baking mix (p=0,001) had significant lower protein content than comparable gluten containing products. Other than protein content, there were no significant difference in nutrient content for flour mix and baking mix. There were no significant differences in nutrient content for clean flours.

4.6.3 **Pasta, dinner and additives, and pizza**

Dinner related products is sorted into the following categories: pasta, dinner and additives, and pizza. The results for these categories are presented in table 8. The pasta category consists of 42 GF- and 30 gluten containing products. This category includes all sorts of pasta, spaghetti, macaroni, fusilli, pasta screws, penne, lasagna plates and tagliatelle. The category dinner and additives consist of 56 GF- and 49 gluten containing products, it includes all products that is used for dinner, except pizza and pasta. The category pizza consists of 11 GF- and 11 gluten containing products, and this includes frozen pizza and pizza crust. Both GF pasta (p= <0,01) and dinner and additives (p= <0,01) have significantly higher carbohydrate content than gluten containing products. For all three categories the protein content is significantly lower for GF products compared to gluten containing counterparts (pasta: p=<0,01, dinner and additives: p=<0,01, pizza: p=0,015). GF pasta has significantly more salt than its counterparts do (p=0,011).

4.6.4 **Snacks & Cake**

The category snacks consist of 85 GF products and 75 gluten containing products. Snacks includes cookies, biscuits, energy bars, crackers and chocolate. The category cake consists of 14 GF products and 13 gluten containing products. This category includes different kinds of sweet cakes. Results for snacks and cake is presented in table 9. GF snacks had a 25% higher content of saturated fat (p=0,055) compared to gluten containing snacks. GF cake had higher content of carbohydrates (p=0,003) and 29% less fiber (p=0,009) compared to gluten containing counterparts. Both snacks (p=0,008) and cake (p=0,006) had significantly lower content of protein than gluten containing counterparts do. On average, GF cakes had 0,4 gram more salt per 100 grams of product (p=0,015).

Table 6. Nutrient content in GF and gluten containing products in the following categories: bread, crispbread and cereals.

	Bread, median (IQR)			**Crispbread, median (IQR)**			**Cereals, median (IQR)**		
Nutrient per 100 g	GF (n=66)	Gluten containing (n=57)	P-Value	GF (n=25)	Gluten containing (n=23)	P-Value	GF (n=61)	Gluten containing (n=45)	P-Value
Calories (kcal)	349 (256-423)	346 (260-346)	0.074	360 (334-381)	347 (280-386)	0.135	360 (251-442)	354 (278-432)	0.973
Fat (g)	6 (1.9 – 16.3)	5 (2.2 – 10.7)	0.086	2.9 (1.9-6.4)	6.3 (2.4-13.8)	0.112	6 (3-20)	7 (3-18)	0.828
Saturated fat (g)	1.2 (0.5-4.9)	0.8 (2.2 – 4.5)	**0.006**	0.8 (0.3-1.4)	0.9 (0.5-2.3)	0.085	1.2 (0.6-6.5)	1.4 (0.5-4.4)	0.715
Carbohydrate (g)	53 (36 – 72)	56 (38 – 65)	0.048	72 (54-77)	59 (46-65)	**0.006**	59 (45-71)	55 (43-63)	**<0.01**
Fiber (g)	4.0 (1.8 – 6.3)	6.8 (3.2 – 9.1)	**0.001**	4.1 (2.4-7.6)	6.5 (2.8-8.2)	0.097	5.1 (2.5-7.7)	6.4 (3.7-8.6)	**0.006**
Sugar (g)	3.0 (0.9 – 7.7)	3.2 (2.0 – 6.4)	0.360	2.8 (1.0-23.9)	3.8 (3.4-17.6)	0.391	3.0 (1.2-26.2)	3.2 (2.1-21)	0.655
Protein (g)	5.2 (3.0 – 8.5)	9.8 (8.3 – 12.0)	**<0.01**	6.2 (4.4-8.4)	9.0 (7.6-11.3)	0.009	5.0 (3.2-7.7)	8.9 (7.2-12.4)	**<0.01**
Salt (g)	0.8 (0.3 – 1.3)	0.9 (01 – 0.9)	0.453	0.8 (0.0-1.4)	0.7 (0.0-0.9)	0.199	0.8 (0.3-1.1)	0.7 (0.2-1)	**0.005**

Notes: IQR = Interquartile range.

P-value is considered significant when it is 0.05 or lower

Table 7. Nutrient content in GF and gluten containing products in the following categories: flour mix, baking mix and clean flours.

	Flour mix, median IQR			Baking mix, median, IQR			Clean flours, median (IQR)		
Nutrient per 100 g	GF (n=12)	Gluten containing (n=7)	P-Value	GF (n=25)	Gluten containing (n=14)	P-Value	GF (n=16)	Gluten containing (n=16)	P-Value
Calories (kcal)	381(277-435)	360 (261-444)	0.239	280 (217-397)	310 (240-380)	0.443	353 (331 - 366)	329 (320 – 340)	0.224
Fat (g)	5.2 (3.6-13.8)	6.3 (3.9-14.5)	0.929	4.9 (2.3-16)	5 (2.2-11)	0.543	3.0 (1.6 – 9.1)	2.5 (1.9 – 4.1)	0.196
Saturated fat (g)	1.9 (0,9-5,7)	1.3 (0.6-3.0)	0.272	1 (0.5-4.5)	0.7 (0.4-4.8)	0.684	0.6 (0.3 – 1.00)	0.3 (0.2 – 0.9)	0.306
Carbohydrate (g)	60 (49-78)	54 (39-65)	0.062	45 (20.6-60.3)	45 (33.5-67.9)	0.716	65 (11 – 71)	61 (55 – 68)	1.00
Fiber (g)	2.8 (2,0-5,6)	7.0 (4.0-9.0)	0.123	4.1 (1.2-5.9)	5.3 (3.1-8.1)	0.623	6.9 (3.8 – 15.0)	10.7 (4.4 – 12.4)	0.861
Sugar (g)	7.3 (1,6-12,0)	3.6 (2.0-16.4)	0.593	3.9 (1.6-12.9)	2.9 (1.8-13.9)	0.484	0.7 (0.00 – 1.8)	2.2 (1.1 – 2.7)	0.278
Protein (g)	5.2 (2,3-8,8)	10.4 (7.9-13.5)	**0.004**	4.2 (2.4-7.7)	8.8 (7.5-11.2)	**0.001**	11.2 (8.1 – 22.0)	11.3 (11.1 – 13.1)	0.605
Salt (g)	0.7 (0,3-1,2)	0.7 (0.2-1.0)	0.119	0.7 (0.3-1.3)	0.7 (0.1-1)	0.118	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.141

Notes: IQR = Interquartile range.

P-value is considered significant when it is 0.05 or lower

Table 8. Nutrient content in GF and gluten containing products in the following categories: pasta, dinner and additives, and pizza.

	Pasta, median (IQR)			Dinner and additives, median (IQR)			Pizza, median (IQR)		
Nutrient content per 100 g	GF (n=42)	Gluten containing (n=30)	P-Value	GF (n=56)	Gluten containing (n=49)	P-Value	GF (n=11)	Gluten containing (n=11)	P-Value
Calories (kcal)	359 (275-430)	338 (247-448)	0.280	351 (267-433)	347 (251-386)	0.215	430 (228-520)	460 (278-500)	0.477
Fat (g)	7.2 (1.5-14)	6.1 (2-16.7)	0.465	6.5 (2.0-14.1)	6.0 (2.0-12.0)	0.633	18.0 (2.9-25.3)	20.0 (4.4-25.0)	0.721
Saturated fat (g)	1.0 (0.5-4.1)	0.8 (0.4-3.3)	0.279	1.2 (0.5-4.5)	0.9 (0.5-3.4)	0.101	1.3 (0.6-10.5)	4.4 (0.7-13.0)	0.889
Carbohydrate (g)	66 (45-76)	58 (40-67)	**<0.01**	62 (42-74)	56 (2-9)	**<0.01**	58 (52-70)	60 (45-63)	0.266
Fiber (g)	4.3 (2-6.9)	5.2 (2.6-6.9)	0.065	4.1 (2.2-8.1)	5.8 (2.3-8.9)	0.208	2.2 (1.2-4.7)	2.8 (1.2-6.1)	0.144
Sugar (g)	3.6 (0.9-14.5)	3.2 (2.1-14.3)	0.871	3.5 (1.1-9.8)	3 (1.6-9.7)	0.268	22.0 (5.9-33.5)	33.0 (3.0-37.0)	1.000
Protein (g)	5.1 (3-7.5)	9.0 (6.6-12)	**<0.01**	5.2 (2.9-8.4)	9.8 (7.0-12.0)	**<0.01**	3.9 (2.8-5.0)	5.5 (4.0-11.0)	**0.013**
Salt (g)	0.8 (0.3-1.1)	0.7 (0.4-1)	**0.011**	0.8 (0.5-1.2)	0.8 (0.2-1.0)	0.163	0.7 (0.3-1.0)	0.7 (0.3-1.0)	0.553

Notes: IQR = Interquartile range.

P-value is considered significant when it is 0.05 or lower

Table 9. Nutrient content in GF and gluten containing products in the following categories: snacks and cakes.

	Snacks, median (IQR)			**Cake, median (IQR)**		
Nutrient per 100 g	GF (n=85)	Gluten containing (n=75)	P-Value	GF (n=14)	Gluten containing (n=13)	P-Value
Calories (kcal)	363 (332-400)	361 (293-379)	0.196	349 (337-371)	352 (258-370)	**<0.01**
Fat (g)	4.7 (1.4-15)	4.4 (1.8-7.8)	0.439	3.2 (1.7-5.2)	3.3 (2.1-4.6)	0.875
Saturated fat (g)	1.0 (0.4-3.4)	0.8 (0.4-2)	0.055	0.5 (0.3-0.8)	0.5 (0.4-1)	0.766
Carbohydrate (g)	64 (45-77)	61 (47-68)	0.113	70 (60-75)	60 (46-67)	**0.003**
Fiber (g)	4.7 (2.5-8.8)	6 (3-10.4)	0.142	5.0 (2.3-7.7)	7.0 (4-13.3)	**0.009**
Sugar (g)	4.5 (1-16.4)	3.6 (2-9.7)	0.386	3.5 (1.4-14)	3.6 (1.9-11.2)	0.807
Protein (g)	7.4 (5-12)	10.0 (7.7-12)	**0.008**	6 (4.7-7.8)	9.8 (7.9-11.3)	**0.006**
Salt (g)	0.5 (0.2-1)	0.6 (0-1)	0.062	0.8 (0.4-1.7)	0.4 (0-0.9)	**0.015**

Notes: IQR = Interquartile range.
P-value is considered significant when it is 0.05 or lower

4.1 Price/Costs

The results for price per kilo of GF products compared to gluten containing products show that the price for GF products is significantly higher than the price for gluten containing products for all categories. The results on price for all 11 categories is presented in table 10. The highest price difference is found in the clean flours-category, where GF clean flours is in average 331% more expensive than gluten containing clean flours. The lowest difference in price is found for pizza where GF pizza cost on average 21% more than gluten containing pizza.

Table 10. Price per kilo of GF and gluten containing products.

Price per kg/Category	GF, median (IQR)	Gluten containing, median (IQR)	P-Value	Difference %
All	170 (109 – 233)	78 (44 – 151)	**<0.01**	118
Bread	185 (115 – 239)	87 (44 – 191)	**<0.01**	113
Crispbread	166 (103 – 242)	74 (45 – 151)	**<0.01**	124
Flour products	191 (148 – 207)	92 (47 – 163)	**0.028**	107
Baking flour	189 (124 – 243)	80 (53 – 145)	**<0.01**	136
Clean flour	125 (77 – 154)	29 (15 – 42)	**<0.01**	331
Cereals	197 (122 – 241)	105 (50 -167)	**<0.01**	88
Pasta	174 (108 – 297)	87 (48 – 187)	**<0.01**	100
Dinner & additives	178 (109 -264)	84 (49 – 157)	**<0.01**	112
Pizza	200 (156 – 436)	165 (98 – 233)	**0.033**	21
Snacks	145 (97 – 217)	79 (33-133)	**<0.01**	84
Cake	129 (105 – 164)	67 (32 – 91)	**0.002**	93

Notes: IQR = Interquartile range.

P-value is considered significant when it is 0.05 or lower

*Note: Difference % = (GF-Gluten containing)/Gluten containing*100*

4.2 Reference diets

4.2.1 Fiber

To find out if it is possible to consume the recommended amount of dietary fiber with GF products, three different dietary GF alternatives are presented. GF alternatives are compared to alternatives with gluten. Results from the comparison of fiber content in GF and gluten containing wholegrain alternatives are presented in table 11 and 12. The difference in price of the different alternatives (both GF and gluten containing) are also present in table 11 and 12. Table 11 shows results of the three different wholegrain alternatives based on products with highest content of fiber for both GF and gluten containing products. Alternative 1) four slices of bread, alternative 2) a plate of wholegrain cereals and two slices of bread, and alternative

3) a portion of oatmeal and a portion of wholegrain pasta. The fiber content was higher in the GF products of alternative 1 (5%) and 3 (29%), and lower (-11%) in alternative 2. In all three alternatives the price was higher in GF products ranging from 90-352% more expensive. Table 12 shows results from three different wholegrain diets, based on the products with the lowest price. The comparison of the different alternatives shows that the content of fiber is lower for GF products in all three alternatives (alternative 1: -21%%, alternative 2: -14%%, and alternative 3: -30%), and the price are higher for GF products in all three alternatives (alternative 1: 620%, alternative 2: 408%, and alternative 3: 73%).

Table 11. Fiber content and price in three different diets with wholegrain products.

Alternative	Fiber content GF (g)	Fiber content gluten containing (g)	Difference %	Price GF (nok)	Price gluten containing (nok)	Difference %
Alternative 1*	13.2	12.6	5%	23.3	6.7	248%
Alternative 2**	21.6	24.3	-11%	25.6	13.5	90%
Alternative 3**	11.6	9.0	29%	11.3	2.5	352%

Note: Based on products with highest fiber content
*Difference % = (GF-gluten containing)/gluten containing*100*
*Alternative 1: Four slices of bread
**Alternative 2: A plate of wholegrain cereals and two slices of bread
***Alternative 3: A plate of oatmeal and a portion of wholegrain pasta

Table 12. Fiber content and price in three different diets with wholegrain products.

Alternative	Fiber content GF (g)	Fiber content gluten containing (g)	Difference %	Price GF (nok)	Price gluten containing (nok)	Difference %
Alternative 1*	5.0	6.4	-21%	9.1	1.3	620
Alternative 2**	9.3	10.8	-14%	9.3	1.8	408
Alternative 3***	5.7	8.2	-30%	4	2.3	73

Note: Based on products with lowest price
*Difference % = (GF-gluten containing)/gluten containing*100*
*Alternative 1: Four slices of bread
**Alternative 2: A plate of wholegrain cereals and two slices of bread
***Alternative 3: A plate of oatmeal and a portion of wholegrain pasta

4.2.2 Nutrient content of a GF diet

To estimate if the nutrient content in a GF diet differ from the nutrient content in a regular diet, estimates from three different GF diets are compared to gluten containing diet, according to intake data in Norkost 3. The amounts in the GF alternative are the same as in Norkost 3. The three different alternatives includes GF alternatives with 1) the highest fiber content, 2) the lowest content of dietary fiber and 3) the lowest price. The results are presented in table 13. It shows that if gluten containing products is exchanged with GF alternatives with the highest amounts of dietary, the GF alternative will provide more calories (5%), a higher number of proteins (7%), carbohydrates (27%), fiber (25%), sugar (32%) and salt (4%), and less fat (9%) than the gluten containing counterparts. If gluten containing products are exchanged with a GF alternative that is low in fiber, the diet will provide more calories (5%), carbohydrates (4%) and sugar (79%), and less protein (3%), fat (11%), fiber (48%) and salt (13%) than comparable gluten containing products. When changing gluten containing products with GF alternatives with lowest price, the diet will provide more sugar (66%) and less calories (5%), protein (1%), fat (5%), carbohydrates (1%), fiber (29%) and salt (21%).

Table 13. Nutrient content in three different GF diets

Diet alternatives	**Kcal**	**Protein (g)**	**Fat (g)**	**Carbohydrate (g)**	**Fiber (g)**	**Sugar (g)**	**Salt (g)**
Norkost 3	2245	96	88	240	24	42	3
Based on highest fiber content	2356	103	81	289	32	65	3.1
-Difference to Norkost 3	5%	7%	-9%	17%	25%	32%	4%
Based GF products low in dietary fiber	2127	93	79	249	13	75	2.6
-Difference to Norkost 3	5%	-3%	-11%	4%	-48%	79%	-13%
Based on lowest price on GF products	2139	95	84	237	17	70	2.4
-Difference to Norkost 3	-5%	-1%	-5%	-1%	-29%	66%	-21%

Note: The diets are compared to numbers on average food consumption and intake of macronutrients from Norkost 3 (gluten containing diet).

*Difference % = (GF-Norkost 3)/Norkost 3*100*

5 DISCUSSION

5.1 Discussion of the method

5.1.1 Data-collection and data-entry

The choice of grocery stores was based on our knowledge about stores with a large assortment of GF products. Including more different grocery stores and other places that sell GF products such as bakeries and health food stores could have affected the results. However, most available GF products in the Norwegian grocery stores is included in the database, and at least the most sold products as included. The time of data collection was a few weeks during the autumn 2019. The time of data collection may have excluded some seasonal products and some out-of-stock products may have been missed (due to that only products available at the time of collection was included). In an attempt to include all available products in the period of collection, a supplemental collection was done after all new products were launched in retail autumn 2019. The data-collection was carried out in the eastern part of Norway (in the county Oslo and Akershus (now called Viken)). Since some of the GF products is voluntary for the grocery stores to add into their assortment, and the assortment is to some degree dependent on demands from the consumers, it is possible that the assortment in the selected stores vary from other stores, and in other counties in Norway.

Concerning the gluten containing benchmark products, one of the criteria was that they should be marked with a keyhole, which indicates that the products have less fat, sugar and salt, and more fiber and wholegrains. Hence, the intention was to investigate if the GF products were comparable to the criteria given in the official dietary recommendations. For gluten containing bread, the criteria for inclusion was that it should have 3/4 or 4/4 squares on the Norwegian bread scale, that indicates how much whole flour or whole grains the bread contains. A bread with 4/4 squares indicate that the bread contain from 76-100% whole flour or whole grains, and a bread with 3/4 squares indicate that the bread contain from 51-75.9% whole flour or whole grains. Hence, if different products were chosen as benchmark, it might have affected the results. Products labeled with “nøkkelhull” or with three or four squares on the bread scale tend to be more expensive than comparable products without these claims (Rao, Afshin, Singh, & Mozaffarian, 2013). If we had chosen the cheapest or the least healthy products as benchmark products it could have affected the price differences, and hence the price difference between GF products and comparable gluten containing products would have been more significant.

The choice of categories was based on intended use, regular food-categories from web-based grocery stores, and sales numbers for GF products in Norway from ACNielsen Norway. The number of products in each category varies from 11 products to 88 products, and in categories with fewer products the estimates could be less reliable. For example, the pizza category only contains 11 different products, and if this category had been included into the category for dinner products the results might have been different. On the other hand, the category for snacks contain 85 GF products and 75 gluten containing products and includes a large variance of different products. If dividing this category into several different categories it might have given a different result. However, this category is not the most important category concerning nutrients and dietary recommendations of a GF diet, and therefore we decided to maintain this as one category.

5.1.2 **Statistics**

The choice of statistical analysis to compare nutrient content in GF versus gluten containing products were based on earlier studies from abroad, and also due to non-normality in the dataset. In the present study non-parametric statistics is used when comparing nutrient content in the two groups. Parametric methods are more powerful than non-parametric methods. But the use of parametric methods require data that are metric and has a particular distribution, preferably normal distribution (Bowers, 2020, p. 219). Further, Wilcoxon signed rank test were used to compare nutrient content and price for GF versus gluten containing products, and to check for statistically significant differences (p-value). Wilcoxon signed-rank test is the non-parametric equivalent of the two-sample *t* test. The Wilcoxon signed rank test has 95 per cent of the power of matched pairs *t* test. Briefly, by using this non-parametric method the matching will reduce the variation within groups, making the variation narrower, and therefore more precise confidence intervals are available for a give sample size. Further, the difference between each pair are calculated. If the two groups are the same, then the two rank sums should be the same, and if it is different, the Wilcoxon method provides a way of determining whether this is due to chance, or represents a statistically significant difference in the population median (Bowers, 2020, pp. 220-222). In the present study GF products were treated as “cases”, while gluten containing counterparts were treated as “controls”, this is similar to a case-control in observational study designs (Bowers, 2020, pp. 140-141). In this study the design of a case-control study is used to compare nutrient content in GF products versus gluten containing counterparts.

When performing a specific statistical test, there is always chance that our results is due to chance instead of any real differences. In this study, we conducted statistical analysis both for all products together, and for separate categories. The sample size of each category vary from 11 to 88 products. The same statistical test was conducted 11 times (multiple testing). This could lead to type 1 and type 2 errors. Meaning, that we reject a null hypothesis when it is true (type 1 error), or not reject the null hypothesis when it is false (type 2 error). The risk of errors is higher when conducting multiple testing. That is, because, each time we rejected the null hypothesis it is possible that we made a mistake (Bowers, 2020, pp. 250-256; Corder & Foreman, 2014, pp. 4-5).

5.2 Discussion of results

In this study we found that the nutrient content in GF food products compared to gluten containing benchmark products, contains less protein and fiber, and more carbohydrates, saturated fat and salt. Furthermore, that GF products compared to gluten containing products, on average are 118% more expensive.

5.2.1 Nutrient content in GF products

The main findings in this comparative nutrient analysis are that GF food products contain less protein and fiber, and more carbohydrates, saturated fat and salt compared to their gluten containing benchmark products. To our knowledge there are no similar studies in any Nordic countries, but similar studies have been performed in Canada (Jamieson et al., 2018), Austria and Germany (Missbach et al., 2015), in the United Kingdom (Fry et al., 2018) and in Spain (Miranda, Lasa, Bustamante, Churruca, & Simon, 2014).

The findings in this study shows that the protein content is significantly lower in GF products compared to gluten containing products overall, and in all categories except in clean flours. Similar results have been found in several other studies worldwide (Fry et al., 2018; Miranda et al., 2014; Missbach et al., 2015). Jamieson et al., (2018) also investigated nutrient content in clean flours and found the that protein content was lower in all categories except for clean flours (Jamieson et al., 2018), which is in line with our results. However, grain-products are not key contributors to dietary protein intake, and it may not be problematic that the protein content in GF products are lower than in comparable gluten containing products. The intake of protein in the general Norwegian population is sufficient, and the key contributors are animal products (Totland et al., 2012). Meat, fish, egg and dairy products contributes with 73% of protein intake, and all of these products are possible to consume for person with CD since it does not contain gluten. In the third national dietary survey on adults in Norway, the intake of all macronutrients was assessed, and the average protein intake was 112 grams per day for men and 96 grams per day for women. Meaning that both for men and women 18% of their total energy intake comes from proteins (Totland et al., 2012). The Nordic recommendations of protein intake recommend adults in the age 18-64 years to have 10-20% of their total energy intake from proteins (Norden, 2014). Protein-rich foods may compensate for inadequate grain and cereal alternatives in a GF diet, suggesting protein sufficiency.

In the present study, fiber content was significantly lower in GF products compared to gluten containing products overall, and in three (bread, cereals and cake) out of ten categories. Similar results were found by Fry et al., from the United Kingdom (Fry et al., 2018). In other studies, they have found lower levels of fiber in pasta, but not for other categories (Jamieson et al., 2018; Miranda et al., 2014; Missbach et al., 2015). In the present study, although median content of fiber was similar between GF and gluten containing categories (with exception of bread, cereals and cake), the median values for fiber in gluten containing products were higher in all categories. The consumption of dietary fiber in Norway is lower than recommended, with an average intake of dietary fiber per day of 26 grams for men and 22 grams for women. The main source of dietary fiber in the Norwegian population is bread and other grain-products, accounting for 53% of the average fiber intake (Totland et al., 2012). Therefore, achieving adequate fiber intake may be difficult on a GF diet.

The content of saturated fat was significantly higher in GF products than comparable gluten containing benchmark products, when comparing all products independent of different categories. When analyzing nutrient values of separate categories, the only category of GF products with significantly higher amounts of saturated fat compared to gluten containing products was bread. This is in line with previous results from similar studies (Fry et al., 2018; Miranda et al., 2014). The key contributors to intake of saturated fatty acids in the Norwegian diet are meat, cheese, butter and milk. Bread only contributes with 4% of the dietary intake of saturated fat for persons with a regular diet (Totland et al., 2012). For persons on a GF diet this number might be higher due to that GF bread contains more saturated fatty acids than comparable gluten containing breads. The intake of saturated fatty acids is recommended to be less than 10% of total energy intake (Norden, 2014). In the Norwegian population, intake of saturated fatty acids is estimated to be 13% of total energy intake (Totland et al., 2012). It is preferable to exchange saturated fat in the diet with monounsaturated and polyunsaturated fat as it is associated with reduced CVD risk (Mozaffarian et al., 2010). Therefore, it is not preferable with a GF diet that provides even more saturated fat than in the regular diet. There were no significant differences in the content of saturated fat in GF flours compared to gluten containing flours, suggesting that baking bread from scratch provides a GF bread with comparable fat content to gluten containing bread.

Sodium derived from salt is an essential nutrient, however, there is a strong association between salt and increased risk of high blood pressure and CVD (Norden, 2014). Overall, GF products contained more salt compared to gluten containing benchmark products. These findings is in line with results from similar studies in other countries (Fry et al., 2018; Jamieson et al., 2018; Miranda et al., 2014). Separated by categories, the salt content was significantly higher in GF products for three of ten categories (cereals, pasta and cake). The Nordic nutrition recommendations advise that the intake of salt should be limited to 6 grams per day (Norden, 2014). Most people in Norway consume around 3 gram of sodium, equivalent to approximately 7,5 grams of salt per day (Totland et al., 2012). The present study found that when analyzing all products together, GF items had significantly higher levels of salt than gluten containing counterparts did. When analyzing each category separately, GF cereals, pasta and cake had significant higher levels of salt. This may indicate that persons following a GF diet consume more salt than recommended, and more salt then the general population. Reducing salt content in food products is on a national cooperation in Norway. The Norwegian salt-partnership (Norwegian: Saltpartnerskapet) has a goal of reducing the salt consumption with 20% within 2021, and 30% within 2025. One of the cooperation areas are to reduce salt content in foods that are sold in Norwegian groceries. The partnership has defined goals on the amount of salt in given product categories. The salt content in bread should be under 1 gram per 100 gram of bread, in crispbread it should be under 0,9 gram of salt per 100 gram of crispbread, in cereals the salt content should be under 0,8 grams per 100 gram of cereals, and in flour mix it should be under 0,8 grams per 100 gram of flour mix

(Helsedirektoratet, 2017). Comparing these goals to our median results on salt content in GF products, GF bread, crispbread cereals, flour mixes and clean flour are within these goals.

Estimates from Norkost 3 (the national dietary survey) suggest that over 60% of salt consumed in the Norwegian adult population comes from food items not explored in this study (e.g. meat, fish, dairy products, egg, fruit & vegetables). When comparing a GF diet based on the products highest in fiber and protein (from our database) to numbers from Norkost 3, there were almost no difference in the amount of salt. Furthermore, the comparison of GF alternatives based on products low in fiber and protein, and products based on lowest price, presents that the amount of salt were lower in the GF alternatives than in Norkost 3. In agreement with previous findings, the content of carbohydrates was significantly higher in GF food products compared to gluten containing benchmark products in five of ten categories (Missbach et al., 2015).

The results from our reference diets presents that nutrient content in a GF diet depends on choice of products. To illustrate, when GF products were chosen based on lowest price, the content of fiber were lower compared to when the products were chosen based on high fiber content. In the comparison of GF dietary alternatives and numbers from Norkost 3, the amount of sugar in the GF products were 66% higher when the choice of product was based on low price. The content of sugar was 79% higher in GF products based on low fiber content compared to Norkost 3.

These findings provide a broad insight into the GF landscape in Norway. Although the ability to generalize to other countries is limited, the nutritional content of the foods reported would be consistent across Norway due to federal regulations for nutrition packaging and fortification. However, many GF products are imported from other countries and could therefore to some extent be generalized to other countries. In this study, we found that there are differences in nutrient content of GF foods available at the Norwegian marked compares to GF products abroad, emphasizing the importance of country-specific GF food databases.

Previous studies from other countries have found that GF products have lower content of iron, folate, zinc, calcium, and B-vitamins (Jamieson et al., 2018; Missbach et al., 2015). As mentioned earlier, when diagnosed with CD, malabsorption of iron, folate, and calcium is common these vitamins and minerals are absorbed in the proximal small bowel (Al-Toma et al., 2019). It would have been interesting to assess if GF products have lower content of these micronutrients. Unfortunately, very few of the products in our database has labelled information about any micronutrient. Hence, it was impossible to do statistical analyses on micronutrient content in GF products compared to comparable gluten containing products.

5.2.2 Costs of gluten free products

In the present study, the price of GF products compared to gluten containing products was significantly higher for all products together and across all ten categories. The largest difference in price was observed for clean flours (331% higher for GF products), baking flours (136% higher for GF products) and crispbread (124% higher for GF products). The lowest difference was observed in the pizza category, in which the difference between GF pizza and gluten containing pizza were 21%. The economic burden of a GF diet is not isolated in Norway, and similar results have been reported from several other countries. Lee, Wolf, Lebwohl, Ciaccio & Green (2019) investigated the economic burden of a GF diet in the United States of America, and found that GF products were more expensive (overall 183%) and that GF products from mass-market producers were 139% more expensive then wheat based version of the same products (Lee, Wolf, Lebwohl, Ciaccio, & Green, 2019).

In a study by Missbach et al. from 2015 where they investigated costs of packaged GF foods in Austria, they found that GF products were substantially higher in cost compared to similar gluten containing products, with a range from 205% higher price for cereals to 267% higher price for GF bread and bakery products (Missbach et al., 2015). Fry, Madden & Fallaize, 2018 found similar results in the United Kingdom. Across 10 food categories the average price for GF products compared with similar gluten containing products were significantly higher (Fry et al., 2018). Further, since a strict GF diet is the only available treatment for persons with CD adherence to the diet is essentially for a successful treatment. It is therefore important that the price of GF products should not be a reason for terminating a GF diet. In a study from Pember & Rush, they investigated motivation for GF diet adherence among adults with and without gluten-related diseases. Their result presents that 10.7% of the participants that terminated a GF diet stopped because they found it to expensive (Pember & Rush, 2016).

In Norway the government has decided to reduce the financial support that persons with CD get due to extra cost for a GF diet with more than 50% (NAV, 2020). Whether this affects the adherence to a GF diet or not is not known. Bread has an important place in the Norwegian diet, and grain products are usually consumed several times a day (Helsedirektoratet., 2019; Totland et al., 2012). Estimations from Norkost 3 presents that on average Norwegian adults consume 184 grams of bread per day (Totland et al., 2012), but in estimations from the Norwegian report on extra expenses due to a GF diet (Forbruksforskningsinstituttet SIFO, 2018) it is only estimated that persons with CD should consume 114 grams of bread each day. It is possible that this has affected the estimations on extra expenses in the Norwegian report on extra expenses due to a GF diet. Further, since there is no data from earlier on the economic burden of a GF diet in Norway, we cannot estimate whether the price has risen or fallen in the recent years.

6 CONCLUSION

To the best of our knowledge this study presents the only comparative nutrient analysis of packed Norwegian GF products and their gluten containing equivalents published to date. This study provides a comprehensive overview of nutrient content and price of GF products on the Norwegian grocery store market.

The results from the presents study indicates the existence of significant differences between the nutrition composition of GF products and comparable gluten containing products. The main findings from the comparative nutrient analysis are that GF products contain less protein and fiber, and more carbohydrates, saturated fat and salt compared to their gluten containing benchmark products. The most crucial nutrient to rise in GF products seems to be dietary fiber since grain-products are the greatest source of dietary fiber. Interestingly, GF clean flours had comparable nutrient content to gluten containing flours.

The price of GF products is significantly higher than comparable gluten containing products, the highest difference in price was found in clean flours (331% higher for GF products).
A reduction in the financial support could lead to that persons with CD can´t afford their medicine, which are a GF diet.

Our estimations on GF reference diets shows that choice of foods in the grocery store can be crucial to reach the national dietary recommendations for macronutrients. The content of dietary fiber in the different wholegrain alternatives when based on products with highest fiber versus lowest price. The content of dietary fiber was 14-30% lower when the alternatives were based on lowest price compared to highest fiber content. In the comparison of results from Norkost 3 and a GF alternative similar to Norkost 3, the content of protein was quite similar in all alternatives (high in dietary fiber and protein, low in dietary fiber and protein, and lowest price). The content of fiber was 25% higher in the GF alternative than Norkost 3, when based on the products highest in fiber. When based on the alternatives with lowest content of dietary fiber and lowest price, the content of dietary fiber in the GF alternatives were 48 (lowest fiber content) and 29% (lowest price) lower than in Norkost 3. This indicates that when the choice of GF wholegrain products is based on price rather than nutrient content it can be difficult to reach the dietary recommendations for intake of dietary fiber. With our results taken into account, persons without any gluten related disease should avoid having a GF diet.

7 FUTURE PERSPECTIVE

In the future it will be necessary to find out if the difference in nutrient content between GF products and gluten containing products will have an effect on the health of persons with CD, and if it could lead to development of non-communicable diseases. Further, to develop new and more nutritious GF products, it is important to find nutritious GF fiber sources, that furthermore will provide positive health effects for persons with gluten related diseases. Another important factor is that persons that have a medical need for GF products, should get knowledge about which GF products that are a healthier alternative.

REFERENCES

Abadie, V., Sollid, L. M., Barreiro, L. B., & Jabri, B. (2011). Integration of genetic and immunological insights into a model of celiac disease pathogenesis. *Annu Rev Immunol, 29*, 493-525. doi:10.1146/annurev-immunol-040210-092915

Abdel-Aal, E. S. M., & Hucl, P. (2002). Amino Acid Composition and In Vitro Protein Digestibility of Selected Ancient Wheats and their End Products. *Journal of Food Composition and Analysis, 15*(6), 737-747. doi:https://doi.org/10.1006/jfca.2002.1094

Adeyeye, A., & Ajewole, K. (1992). Chemical composition and fatty acid profiles of cereals in Nigeria. *Food Chemistry, 44*(1), 41-44. doi:https://doi.org/10.1016/0308-8146(92)90255-Z

Agriculture and Agri-food Canada. (2014, 10.11.2017). "Gluten Free" Claims in the Marketplace. Retrieved from https://www5.agr.gc.ca/eng/industry-markets-and-trade/canadian-agri-food-sector-intelligence/processed-food-and-beverages/trends-and-market-opportunities-for-the-food-processing-sector/gluten-free-claims-in-the-marketplace/?id=1397673574797

Al-Bawardy, B., Codipilly, D., Rubio-Tapia, A., Bruining, D., Hansel, S., & Murray, J. (2017). Celiac disease: a clinical review. *Abdominal Radiology, 42*(2), 351-360. doi:10.1007/s00261-016-1034-y

Al-Toma, A., Volta, U., Auricchio, R., Castillejo, G., Sanders, D. S., Cellier, C., . . . Lundin, K. E. A. (2019). European Society for the Study of Coeliac Disease (ESsCD) guideline for coeliac disease and other gluten-related disorders. *United European Gastroenterology Journal, 7*(5), 583-613. doi:10.1177/2050640619844125

Book, J. L., Zone, L. J., & Neuhausen, L. S. (2003). Pprevalence of Celiac Disease Among Relatives of Sib Pairs With Celiac Disease in U.S. Families. *American Journal of Gastroenterology, 98*(2), 377-381. doi:10.1111/j.1572-0241.2003.07238.x

Bowers, D. (2020). *Medical statistics from scratch : an introduction for health professionals* (Fourth edition. ed.). Hoboken, New Jersey: Wiley.

Canfora, E. E., Meex, R. C. R., Venema, K., & Blaak, E. E. (2019). Gut microbial metabolites in obesity, NAFLD and T2DM. *Nature Reviews Endocrinology, 15*(5), 261-273. doi:10.1038/s41574-019-0156-z

Carlsson, A., Axelsson, I., Borulf, S., Bredberg, A., Forslund, M., Lindberg, B., . . . Ivarsson, S. A. (1998). Prevalence of IgA-antigliadin antibodies and IgA-antiendomysium antibodies related to celiac disease in children with Down syndrome. *Pediatrics, 101*(2), 272-275. doi:10.1542/peds.101.2.272

Carnicer, J., Farre, C., Varea, V., Vilar, P., Moreno, J., & Artigas, J. (2001). Prevalence of coeliac disease in Down's syndrome. *Eur J Gastroenterol Hepatol, 13*(3), 263-267. doi:10.1097/00042737-200103000-00008

Caruso, R., Pallone, F., Stasi, E., Romeo, S., & Monteleone, G. (2013). Appropriate nutrient supplementation in celiac disease. *Annals of Medicine, 45*(8), 522-531. doi:10.3109/07853890.2013.849383

Castro, M., Crino, A., Papadatou, B., Purpura, M., Giannotti, A., Ferretti, F., . . . et al. (1993). Down's syndrome and celiac disease: the prevalence of high IgA-antigliadin antibodies and HLA-DR and DQ antigens in trisomy 21. *J Pediatr Gastroenterol Nutr, 16*(3), 265-268.

Catassi, C., Elli, L., Bonaz, B., Bouma, G., Carroccio, A., Castillejo, G., . . . Fasano, A. (2015). Diagnosis of Non-Celiac Gluten Sensitivity (NCGS): The Salerno Experts' Criteria. *Nutrients, 7*(6). doi:10.3390/nu7064966

Corder, G. W., & Foreman, D. I. (2014). *Nonparametric statistics : a step-by-step approach*(2nd ed. ed.).

Day, L., Augustin, M. A., Batey, I. L., & Wrigley, C. W. (2006). Wheat-gluten uses and industry needs. *Trends in Food Science & Technology, 17*(2), 82-90. doi:10.1016/j.tifs.2005.10.003

De Re, V., Magris, R., Cannizzaro, R., & De Re, V. (2017). New Insights into the Pathogenesis of Celiac Disease. *Frontiers in medicine, 4*, 137-137. doi:10.3389/fmed.2017.00137

Dieterich, W., & Zopf, Y. (2019). Gluten and FODMAPS-Sense of a Restriction/When Is Restriction Necessary? *Nutrients, 11*(8), 1957. doi:10.3390/nu11081957

Dubé, C., Rostom, A., Sy, R., Cranney, A., Saloojee, N., Garritty, C., . . . Moher, D. (2005). The prevalence of celiac disease in average-risk and at-risk Western European populations: A systematic review. *Gastroenterology, 128*, S57-67. doi:10.1053/j.gastro.2005.02.014

Dydensborg Sander, S., Nybo Andersen, A. M., Murray, J. A., Karlstad, O., Husby, S., & Stordal, K. (2019). Association Between Antibiotics in the First Year of Life and Celiac Disease. *Gastroenterology, 156*(8), 2217-2229. doi:10.1053/j.gastro.2019.02.039

European Food Safety Authority. (2010). Scientific Opinion on Dietary Reference Values for carbohydrates and dietary fibre. *EFSA Journal, 8*(3), n/a-n/a. doi:10.2903/j.efsa.2010.1462

Failla, P., Ruberto, C., Pagano, M. C., Lombardo, M., Bottaro, G., Perichon, B., . . . Ragusa, A. (1996). Celiac disease in Down's syndrome with HLA serological and molecular studies. *J Pediatr Gastroenterol Nutr, 23*(3), 303-306. doi:10.1097/00005176-199610000-00016

Fasano, A. (2005). Clinical presentation of celiac disease in the pediatric population. *Gastroenterology, 128*(4), S68-S73. doi:10.1053/j.gastro.2005.02.015

Fasano, A., Berti, I., Gerarduzzi, T., Not, T., Colletti, R. B., Drago, S., . . . Horvath, K. (2003). Prevalence of Celiac Disease in At-Risk and Not-At-Risk Groups in the United States: A Large Multicenter Study. *Archives of Internal Medicine, 163*(3), 286-292. doi:10.1001/archinte.163.3.286

Fine, K. D. (1996). The Prevalence of Occult Gastrointestinal Bleeding in Celiac Sprue. *New England Journal of Medicine, 334*(18), 1163-1167. doi:10.1056/nejm199605023341804

Lov om folketrygd (LOV-1997-02-28-19), (1997).

Forbruksforskningsinstituttet SIFO. (2018). *Kartlegging av ekstrautgifter*. (Oppdragsrapport nr. 6 - 2018). Oslo Retrieved from http://www.hioa.no/Om-OsloMet/Senter-for-velferds-og-arbeidslivsforskning/SIFO/Publikasjoner-fra-SIFO/Kartlegging-av-ekstrautgifter

Ford, A. C., Chey, W. D., Talley, N. J., Malhotra, A., Spiegel, B. M., & Moayyedi, P. (2009). Yield of diagnostic tests for celiac disease in individuals with symptoms suggestive of irritable bowel syndrome: systematic review and meta-analysis. *Arch Intern Med, 169*(7), 651-658. doi:10.1001/archinternmed.2009.22

French, S. A. (2003). Pricing effects on food choices. *J Nutr, 133*(3), 841s-843s. doi:10.1093/jn/133.3.841S

Fry, L., Madden, A. M., & Fallaize, R. (2018). An investigation into the nutritional composition and cost of gluten-free versus regular food products in the UK. *Journal of Human Nutrition and Dietetics, 31*(1), 108-120. doi:10.1111/jhn.12502

Gale, L., Wimalaratna, H., Brotodiharjo, A., & Duggan, J. M. (1997). Down's syndrome is strongly associated with coeliac disease. *Gut, 40*(4), 492-496. doi:10.1136/gut.40.4.492

Garcia-Mazcorro, J. F., Noratto, G., & Remes-Troche, J. M. (2018). The Effect of Gluten-Free Diet on Health and the Gut Microbiota Cannot Be Extrapolated from One Population to Others. *Nutrients, 10*(10). doi:10.3390/nu10101421

George, E. K., Mearin, M. L., Bouquet, J., von Blomberg, B. M., Stapel, S. O., van Elburg, R. M., & de Graaf, E. A. (1996). High frequency of celiac disease in Down syndrome. *J Pediatr, 128*(4), 555-557. doi:10.1016/s0022-3476(96)70369-4

Gorinstein, S., Pawelzik, E., Delgado-Licon, E., Haruenkit, R., Weisz, M., & Trakhtenberg, S. (2002). Characterisation of pseudocereal and cereal proteins by protein and amino acid analyses. *Journal of the Science of Food and Agriculture, 82*(8), 886-891. doi:10.1002/jsfa.1120

Greco, L., Romino, R., Coto, I., Di Cosmo, N., Percopo, S., Maglio, M., . . . Stazi, M. A. (2002). The first large population based twin study of coeliac disease. *Gut, 50*(5), 624-628. doi:10.1136/gut.50.5.624

Hall, N. J., Rubin, G., & Charnock, A. (2009). Systematic review: adherence to a gluten-free diet in adult patients with coeliac disease. In (Vol. 30, pp. 315-330). Oxford, UK.

Hansen, D., Brock-Jacobsen, B., Lund, E., Bjorn, C., Hansen, L. P., Nielsen, C., . . . Husby, S. (2006). Clinical benefit of a gluten-free diet in type 1 diabetic children with screening-detected celiac disease: a population-based screening study with 2 years' follow-up. *Diabetes Care, 29*(11), 2452-2456. doi:10.2337/dc06-0990

Haupt-Jorgensen, M., Holm, L. J., Josefsen, K., & Buschard, K. (2018). Possible Prevention of Diabetes with a Gluten-Free Diet. *Nutrients, 10*(11). doi:10.3390/nu10111746

Helsedirektoratet. (2011). *Kostråd for å fremme folkehelsen og forebygge kroniske sykdommer : metodologi og vitenskapelig kunnskapsgrunnlag*. Oslo: Helsedirektoratet.

Helsedirektoratet. (2014). *Anbefalinger om kosthold, ernæring og fysisk aktivitet*.

Helsedirektoratet. (2017, 28.06.2019). Salt og Saltpartnerskapet. Retrieved from https://www.helsedirektoratet.no/tema/kosthold-og-ernaering/matbransje-serveringsmarked-og-arbeidsliv/salt-og-saltpartnerskapet#veiledende-saltmaal-i-partnerskapet-2019%E2%80%932021

Helsedirektoratet. (2019). Utviklingen i norsk kosthold 2019 : matforsyningsstatistikk og forbruksundersøkelser.

Husby, S., Koletzko, S., Korponay-Szabó, I., Kurppa, K., Mearin, M. L., Ribes-Koninckx, C., . . . Wessels, M. (2020). European Society Paediatric Gastroenterology, Hepatology and Nutrition Guidelines for Diagnosing Coeliac Disease 2020. *Journal of Pediatric Gastroenterology and Nutrition, 70*(1), 141-156. doi:10.1097/mpg.0000000000002497

Jamieson, J. A., Weir, M., & Gougeon, L. (2018). Canadian packaged gluten-free foods are less nutritious than their regular gluten-containing counterparts.(Report). *PeerJ, 6*(11), e5875. doi:10.7717/peerj.5875

Jansson, U., & Johansson, C. (1995). Down syndrome and celiac disease. *J Pediatr Gastroenterol Nutr, 21*(4), 443-445. doi:10.1097/00005176-199511000-00012

Kabbani, T. A., Kelly, C. P., Betensky, R. A., Hansen, J., Pallav, K., Villafuerte–Gálvez, J. A., . . . Leffler, D. A. (2013). Patients With Celiac Disease Have a Lower Prevalence of Non–Insulin-Dependent Diabetes Mellitus and Metabolic Syndrome. *Gastroenterology, 144*(5), 912-917.e911. doi:10.1053/j.gastro.2013.01.033

Kahrs, C. R., Chuda, K., Tapia, G., Stene, L. C., Mårild, K., Rasmussen, T., . . . Størdal, K. (2019). Enterovirus as trigger of coeliac disease: nested case-control study within prospective birth cohort. *BMJ, 364*. doi:10.1136/bmj.l231

Kang, J. Y., Kang, A. H., Green, A., Gwee, K. A., & Ho, K. Y. (2013). Systematic review: worldwide variation in the frequency of coeliac disease and changes over time. *Aliment Pharmacol Ther, 38*(3), 226-245. doi:10.1111/apt.12373

Keet, C. A., Matsui, E. C., Mudd, K. E., Paterakis, M., & Wood, R. A. (2008). The Natural History of Wheat Allergy. *The Journal of Allergy and Clinical Immunology, 121*(2), S236-S236. doi:10.1016/j.jaci.2007.12.934

Kizilgul, M., Ozcelik, O., Beysel, S., Akinci, H., Kan, S., Ucan, B., . . . Cakal, E. (2017). Screening for celiac disease in poorly controlled type 2 diabetes mellitus: worth it or not? *BMC Endocr Disord, 17*(1), 62. doi:10.1186/s12902-017-0212-4

Kylokas, A., Kaukinen, K., Huhtala, H., Collin, P., Maki, M., & Kurppa, K. (2016). Type 1 and type 2 diabetes in celiac disease: prevalence and effect on clinical and histological presentation. *BMC Gastroenterol, 16*(1), 76. doi:10.1186/s12876-016-0488-2

Lairon, D., Arnault, N., Bertrais, S., Planells, R., Clero, E., Hercberg, S., & Boutron-Ruault, M. C. (2005). Dietary fiber intake and risk factors for cardiovascular disease in French adults. *Am. J. Clin. Nutr., 82*(6), 1185-1194.

Lee, A. R., Wolf, R. L., Lebwohl, B., Ciaccio, E. J., & Green, P. H. R. (2019). Persistent Economic Burden of the Gluten Free Diet. *Nutrients, 11*(2). doi:10.3390/nu11020399

Lindfors, K., Ciacci, C., Kurppa, K., Lundin, K. E. A., Makharia, G. K., Mearin, M. L., . . . Kaukinen, K. (2019). Coeliac disease. *Nat Rev Dis Primers, 5*(1), 3. doi:10.1038/s41572-018-0054-z

Liu, S., Stampfer, M. J., Hu, F. B., Giovannucci, E., Rimm, E., Manson, J. E., . . . Willett, W. C. (1999). Whole-grain consumption and risk of coronary heart disease: results from the Nurses' Health Study. *American Journal of Clinical Nutrition, 70*(3), 412. doi:10.1093/ajcn/70.3.412

Lohi, S., Mustalahti, K., Kaukinen, K., Laurila, K., Collin, P., Rissanen, H., . . . Maki, M. (2007). Increasing prevalence of coeliac disease over time. *Alimentary Pharmacology & Therapeutics, 26*(9), 1217-1225. doi:10.1111/j.1365-2036.2007.03502.x

Ludvigsson, J. F., Card, T. R., Kaukinen, K., Bai, J., Zingone, F., Sanders, D. S., & Murray, J. A. (2015). Screening for celiac disease in the general population and in high-risk groups. *United European Gastroenterology Journal, 3*(2), 106-120. doi:10.1177/2050640614561668

Ludvigsson, J. F., Ludvigsson, J., Ekbom, A., & Montgomery, S. M. (2006). Celiac Disease and Risk of Subsequent Type 1 Diabetes. *A general population cohort study of children and adolescents, 29*(11), 2483-2488. doi:10.2337/dc06-0794

Lund-Blix, N. A., Mårild, K., Tapia, G., Norris, J. M., Stene, L. C., & Størdal, K. (2019). Gluten Intake in Early Childhood and Risk of Celiac Disease in Childhood: A Nationwide Cohort Study. *American Journal of Gastroenterology, 114*(8), 1299-1306. doi:10.14309/ajg.0000000000000331

Forskrift om endring i forskrift om matinformasjon til forbrukerne (Forskfrift nr: 1497), 2015-0181 C.F.R. (2015).

Megiorni, F., & Pizzuti, A. (2012). HLA-DQA1 and HLA-DQB1 in Celiac disease predisposition: practical implications of the HLA molecular typing. *Journal of Biomedical Science, 19*(1), 88. doi:10.1186/1423-0127-19-88

Melini, V., Melini, F., & Melini, V. (2019). Gluten-Free Diet: Gaps and Needs for a Healthier Diet. *Nutrients, 11*(1). doi:10.3390/nu11010170

Miranda, J., Lasa, A., Bustamante, M., Churruca, I., & Simon, E. (2014). Nutritional Differences Between a Gluten-free Diet and a Diet Containing Equivalent Products with Gluten. *Plant Foods for Human Nutrition, 69*(2), 182-187. doi:10.1007/s11130-014-0410-4

Missbach, B., Schwingshackl, L., Billmann, A., Mystek, A., Hickelsberger, M., Bauer, G., & Konig, J. (2015). Gluten-free food database: the nutritional quality and cost of packaged gluten-free foods. *PeerJ, 3*(10), e1337. doi:10.7717/peerj.1337

Montonen, J., Knekt, P., Jarvinen, R., Aromaa, A., & Reunanen, A. (2003). Whole-grain and fiber intake and the incidence of type 2 diabetes. *American Journal of Clinical Nutrition, 77*(3), 622. doi:10.1093/ajcn/77.3.622

Mozaffarian, D. (2016). Dietary and Policy Priorities for Cardiovascular Disease, Diabetes, and Obesity: A Comprehensive Review. *Circulation, 133*(2), 187-225. doi:10.1161/circulationaha.115.018585

Mozaffarian, D., Micha, R., & Wallace, S. (2010). Effects on coronary heart disease of increasing polyunsaturated fat in place of saturated fat: a systematic review and meta-analysis of randomized controlled trials. *PLoS Med, 7*(3), e1000252. doi:10.1371/journal.pmed.1000252

NAV. (2020, 13.01.2020). Grunn- og hjelpestønad Retrieved from https://www.nav.no/no/nav-og-samfunn/kontakt-nav/oversikt-over-satser/grunn-og-hjelpestonad_kap

Newberry, C., McKnight, L., Sarav, M., & Pickett-Blakely, O. (2017). Going Gluten Free: the History and Nutritional Implications of Today's Most Popular Diet. *Current Gastroenterology Reports, 19*(11), 54. doi:10.1007/s11894-017-0597-2

Niewinski, M. M. (2008). Advances in Celiac Disease and Gluten-Free Diet. *Journal of the American Dietetic Association, 108*(4), 661-672. doi:10.1016/j.jada.2008.01.011

Nilsson, N., Sjölander, S., Baar, A., Berthold, M., Pahr, S., Vrtala, S., . . . Nilsson, C. (2015). Wheat allergy in children evaluated with challenge and IgE antibodies to wheat components. *Pediatric Allergy and Immunology, 26*(2), 119-125. doi:10.1111/pai.12334

Norden. (2014). *Nordic nutrition recommendations 2012 : integrating nutrition and physical activity*(5th ed. ed., Vol. 2014:002).

Pember, S. E., ,, & Rush, S. E. (2016). Motivation for Gluten-Free Diet Adherence among Adults with and without a Clinically Diagnosed Gluten-Related Illness. *Californian Journal of Health Promotion, 14*(2). doi:10.32398/cjhp.v14i2.1876

Penagini, F., Dilillo, D., Meneghin, F., Mameli, C., Fabiano, V., & Zuccotti, G. (2013). Gluten-Free Diet in Children: An Approach to a Nutritionally Adequate and Balanced Diet. *Nutrients, 5*(11), 4553-4565. doi:10.3390/nu5114553

Petruzziello, L., Iacopini, F., Bulajic, M., Shah, S., & Costamagna, G. (2006). Review article: uncomplicated diverticular disease of the colon. In (Vol. 23, pp. 1379-1391). Oxford, UK.

Poulain, C., Johanet, C., Delcroix, C., Lévy-Marchal, C., & Tubiana-Rufi, N. (2007). Prevalence and clinical features of celiac disease in 950 children with type 1 diabetes in France. *Diabetes & metabolism, 33*(6), 453-458. doi:10.1016/j.diabet.2007.06.004

Pourpak, Z., Mesdaghi, M., Mansouri, M., Kazemnejad, A., Toosi, S. B., & Farhoudi, A. (2005). Which cereal is a suitable substitute for wheat in children with wheat allergy? *Pediatric Allergy and Immunology, 16*(3), 262-266. doi:10.1111/j.1399-3038.2005.00263.x

Ransford, R. A., Hayes, M., Palmer, M., & Hall, M. J. (2002). A controlled, prospective screening study of celiac disease presenting as iron deficiency anemia. *J Clin Gastroenterol, 35*(3), 228-233. doi:10.1097/00004836-200209000-00006

Rao, M., Afshin, A., Singh, G., & Mozaffarian, D. (2013). Do healthier foods and diet patterns cost more than less healthy options? A systematic review and meta-analysis. *BMJ Open, 3*(12), e004277. doi:10.1136/bmjopen-2013-004277

Rosentrater, K. A., & Evers, A. D. (2018). Chapter 1 - Introduction to cereals and pseudocereals and their production. In K. A. Rosentrater & A. D. Evers (Eds.), *Kent's Technology of Cereals (Fifth Edition)* (pp. 1-76): Woodhead Publishing.

Rubio-Tapia, A., Ludvigsson, J. F., Brantner, T. L., Murray, J. A., & Everhart, J. E. (2012). The prevalence of celiac disease in the United States. *Am J Gastroenterol, 107*(10), 1538-1544; quiz 1537, 1545. doi:10.1038/ajg.2012.219

Santoro, L., De Matteis, G., Fuorlo, M., Giupponi, B., Martone, A. M., Landi, F., . . . Santoliquido, A. (2017). Atherosclerosis and cardiovascular involvement in celiac disease: the role of autoimmunity and inflammation. *Eur Rev Med Pharmacol Sci, 21*(23), 5437-5444. doi:10.26355/eurrev_201712_13932

Saturni, L., Ferretti, G., & Bacchetti, T. (2010). The Gluten-Free Diet: Safety and Nutritional Quality. *Nutrients, 2*(1), 16-34. doi:10.3390/nu2010016

Schuppan, D., & Zimmer, K.-P. (2013). The diagnosis and treatment of celiac disease. *Deutsches Arzteblatt international, 110*(49), 835-846. doi:10.3238/arztebl.2013.0835

See, J. A., Kaukinen, K., Makharia, G. K., Gibson, P. R., & Murray, J. A. (2015). Practical insights into gluten-free diets. *Nat Rev Gastroenterol Hepatol, 12*(10), 580-591. doi:10.1038/nrgastro.2015.156

Shepherd, S. J., & Gibson, P. R. (2013). Nutritional inadequacies of the gluten-free diet in both recently-diagnosed and long-term patients with coeliac disease. *Journal of Human Nutrition and Dietetics, 26*(4), 349-358. doi:10.1111/jhn.12018

Sicherer, S. H., & Sampson, H. A. (2018). Food allergy: A review and update on epidemiology, pathogenesis, diagnosis, prevention, and management. *The Journal of Allergy and Clinical Immunology, 141*(1), 41-58. doi:10.1016/j.jaci.2017.11.003

Silvester, J. A., & Rashid, M. (2007). Long-term follow-up of individuals with celiac disease: An evaluation of current practice guidelines. *Canadian Journal of Gastroenterology, 21*(9), 557-564. doi:10.1155/2007/342685

Singh, P., Arora, A., Strand, T. A., Leffler, D. A., Catassi, C., Green, P. H., . . . Makharia, G. K. (2018). Global Prevalence of Celiac Disease: Systematic Review and Meta-analysis. *Clin Gastroenterol Hepatol, 16*(6), 823-836.e822. doi:10.1016/j.cgh.2017.06.037

Skodje, G. I., Minelle, I. H., Rolfsen, K. L., Iacovou, M., Lundin, K. E. A., Veierød, M. B., & Henriksen, C. (2019). Dietary and symptom assessment in adults with self-reported non-coeliac gluten sensitivity. *Clinical Nutrition ESPEN, 31*, 88-94. doi:10.1016/j.clnesp.2019.02.012

Skovbjerg, H., Tarnow, L., Locht, H., & Parving, H. H. (2005). The prevalence of coeliac disease in adult Danish patients with type 1 diabetes with and without nephropathy. *Diabetologia, 48*(7), 1416-1417. doi:10.1007/s00125-005-1776-5

Sollid, L. M., Markussen, G., Ek, J., Gjerde, H., Vartdal, F., & Thorsby, E. (1989). Evidence for a primary association of celiac disease to a particular HLA-DQ alpha/beta heterodimer. *J Exp Med, 169*(1), 345-350. doi:10.1084/jem.169.1.345

Steffen, L. M., Jacobs, D. R., Stevens, J., Shahar, E., Carithers, T., Folsom, A. R., & Steffen, L. M. (2003). Associations of whole-grain, refined-grain, and fruit and vegetable consumption with risks of all-cause mortality and incident coronary artery disease and ischemic stroke: the Atherosclerosis Risk in Communities (ARIC) Study. *The American journal of clinical nutrition, 78*(3), 383-390. doi:10.1093/ajcn/78.3.383

Stene, L. C., Honeyman, M. C., Hoffenberg, E. J., Haas, J. E., Sokol, R. J., Emery, L., . . . Rewers, M. (2006). Rotavirus Infection Frequency and Risk of Celiac Disease

Autoimmunity in Early Childhood: A Longitudinal Study. *The American Journal of Gastroenterology, 101*(10), 2333. doi:10.1111/j.1572-0241.2006.00741.x

Stevenson, L., Phillips, F., O'Sullivan, K., & Walton, J. (2012). Wheat bran: its composition and benefits to health, a European perspective. *International Journal of Food Sciences and Nutrition, 63*(8), 1001-1013. doi:10.3109/09637486.2012.687366

Storm, W. (1990). Prevalence and diagnostic significance of gliadin antibodies in children with Down syndrome. *Eur J Pediatr, 149*(12), 833-834. doi:10.1007/bf02072069

Størdal, K., White, R. A., & Eggesbø, M. (2013). Early Feeding and Risk of Celiac Disease in a Prospective Birth Cohort. *Pediatrics, 132*(5), e1202-e1209. doi:10.1542/peds.2013-1752

The Nielson Company. (2015). *We are what we eat: Healthy eating trends around the world*. Retrieved from https://www.nielsen.com/wp-content/uploads/sites/3/2019/04/january-2015-global-health-and-wellness-report.pdf

Totland, T. H., Helsedirektoratet, Universitetet i, O., & Mattilsynet. (2012). *Norkost 3 : en landsomfattende kostholdsundersøkelse blant menn og kvinner i Norge i alderen 18-70 år, 2010-11*. Oslo: Helsedirektoratet.

Turner, J. (2018). Diagnosis of Celiac Disease: Taking a Bite Out of the Controversy. *Digestive Diseases and Sciences, 63*(6), 1384-1391. doi:10.1007/s10620-018-5050-3

van Autreve, J. E., Weets, I., Gulbis, B., Vertongen, F., Gorus, F. K., & van der Auwera, B. J. (2004). The rare HLA-DQA1*03-DQB1*02 haplotype confers susceptibility to type 1 diabetes in whites and is preferentially associated with early clinical disease onset in male subjects. *Hum Immunol, 65*(7), 729-736. doi:10.1016/j.humimm.2004.04.004

van Heel, D. A., Franke, L., Hunth, K. A., Gwilliam, R., Zhernakova, A., Inouye, M., . . . Wijmenga, C. (2007). A genome-wide association study for celiac disease identifies risk variants in the region harboring IL2 and IL2'.(BRIEF COMMUNICATIONS)(Interleukin-2)(Clinical report). *Nature Genetics, 39*(7), 827. doi:10.1038/ng2058

Victorien, M. W., & Cisca, W. (2008). Genetic Background of Celiac Disease and Its Clinical Implications. *The American Journal of Gastroenterology, 103*(1), 190. doi:10.1111/j.1572-0241.2007.01471.x

Virta, L. J., Kaukinen, K., & Collin, P. (2009). Incidence and prevalence of diagnosed coeliac disease in Finland: results of effective case finding in adults. *Scand J Gastroenterol, 44*(8), 933-938. doi:10.1080/00365520903030795

Vujasinovic, M., Tepes, B., Volfand, J., & Rudolf, S. (2015). Exocrine pancreatic insufficiency, MRI of the pancreas and serum nutritional markers in patients with coeliac disease. In: The Fellowship of Postgraduate Medicine.

West, J., Fleming, K. M., Tata, L. J., Card, T. R., & Crooks, C. J. (2014). Incidence and prevalence of celiac disease and dermatitis herpetiformis in the UK over two decades: population-based study. *Am J Gastroenterol, 109*(5), 757-768. doi:10.1038/ajg.2014.55

Whelton, P. S., Hyre, D. A., Pedersen, K. B., Yi, K. Y., Whelton, K. P., & He, K. J. (2005). Effect of dietary fiber intake on blood pressure: a meta-analysis of randomized, controlled clinical trials. *Journal of Hypertension, 23*(3), 475-481. doi:10.1097/01.hjh.0000160199.51158.cf

Wieser, H. (2007). Chemistry of gluten proteins. *Food microbiology, 24*, 115-119. doi:10.1016/j.fm.2006.07.004

Wild, D., Robins, G. G., Burley, V. J., & Howdle, P. D. (2010). Evidence of high sugar intake, and low fibre and mineral intake, in the gluten-free diet. *Alimentary Pharmacology & Therapeutics, 32*(4), 573-581. doi:10.1111/j.1365-2036.2010.04386.x

Yánez, E., Zacarías, I., Granger, D., Vásquez, M., & Estévez, A. M. (1994). [Chemical and nutritional characterization of amaranthus (Amaranthus cruentus)]. *Archivos latinoamericanos de nutricion, 44*(1), 57-62. Retrieved from http://europepmc.org/abstract/MED/7717808

Zuccotti, G., Fabiano, V., Dilillo, D., Picca, M., Cravidi, C., & Brambilla, P. (2013). Intakes of nutrients in I talian children with celiac disease and the role of commercially available gluten-free products. *Journal of Human Nutrition and Dietetics, 26*(5), 436-444. doi:10.1111/jhn.12026

Aalen, O. O., & Frigessi, A. (2018). *Statistiske metoder i medisin og helsefag* (2. utg. ed.). Oslo: Gyldendal akademisk.

8 ATTACHMENTS

	A	B	C	D	E	F	G	H	I	J	K
2								per 100g	g/100g		
3	Produktnummer	Produktkategori	Productname	Amount in grams	Price	Price per kilo	Beregnet pris per	Calories/energy	Fat	Saturated fat	MUFA
4	1,0	8,0	Kikkoman Soyasaus glutenfri	250	51,9		207,6	53,0	0,0	0,0	0,0
5	2,0	1,0	Nestle Min glutenfri Grøt, Eple og Banan	240	35,9		149,6	430,0	11,0	0,5	x
6	3,0	8,0	Toro Lasagne Glutenfri	300	51,9		173,0	161,0	7,7	4,1	x
7	4,0	6,0	Paradiso Pizzamel Glutenfri	500	48,9	97,8	97,8	351,0	0,6	0,2	x
8	5,0	9,0	Semper Skorpor Glutenfri m/kardemomme	150	51,8	345,3	345,3	394,0	6,0	2,9	x
9	6,0	1,0	Synnøve Granola Glutenfri Bringebær	350	64,9	185,4	185,4	428,0	17,0	3,0	x
10	7,0	8,0	Kikkoman Teriyaki Glutenfri	250	69,9	279,6	279,6	101,0	0,0	0,0	0,0
11	8,0	10,0	Grandiosa Pizza Glutenfri (frossen)	590	69,9	118,5	118,5	201,0	7,7	4,2	x
12	9,0	9,0	Brisk Knekkebrød Glutenfri	150	37,9	252,7	252,7	532,0	43,9	5,3	x
13	10,0	2,0	Bakehuset Kjernebrød Glutenfri	500	53,9	107,8	107,8	293,0	14,1	1,9	x
14	11,0	9,0	Sigdal Knekkebrød Glutenfri	190	39,9	210,0	210,0	543,0	39,6	4,9	x
15	12,0	1,0	Axa Havregryn Glutenfri	900	38,5	42,8	42,8	376,0	7,0	1,4	x
16	13,0	3,0	Barilla Spagetti Glutenfri	400	33,5	83,8	83,8	359,0	1,8	0,9	x
17	14,0	2,0	Fria Grovbrød Glutenfri (frossen)	500	58,9	117,8	117,8	260,0	3,4	0,6	x
18	15,0	10,0	Peppes Pizzabunn Glutenfri	260	52,9	203,5	203,5	274,0	8,1	0,7	x
19	16,0	2,0	Fria Havrebrød Glutenfri (frossen)	500	71,9	143,8	143,8	246,0	3,4	0,7	x
20	17,0	3,0	Barilla Fusilli Glutenfri	400	32,9	82,3	82,3	359,0	1,8	0,3	x
21	18,0	5,0	Schar CHOCO CHIP COOKIES Glutenfri	200	28,5	142,5	142,5	523,0	28,0	15,0	x
22	19,0	3,0	Semper Tagliatelle m/egg Glutenfri	250	53,5	214,0	214,0	374,0	3,5	1,8	x
23	20,0	2,0	Schar Flerkorn Brød Glutenfri (langtidsholdbare br	300	45,9	153,0	153,0	248,0	6,2	0,9	x
24	21,0	2,0	Schar Ciabatta Glutenfri (langtidsholdsbare brød)	200	30,9	154,5	154,5	213,0	1,8	0,3	x
25	22,0	2,0	Fria Fiberbrød Glutenfri (frossen)	500	65,9	131,8	131,8	282,0	8,6	1,2	x
26	23,0	2,0	Schar Landbrot Brød Glutenfri (langtidsholdbart br	275	42,9	156,0	156,0	220,0	3,0	0,4	x
27	24,0	7,0	Toro Vafler Mix Glutenfri	246	34,9		141,9	305,0	14,0	1,2	x
28	25,0	8,0	Findus Fiskepinner Glutenfri (frossen)	360	42,5	118,1	118,1	204,0	9,1	0,8	x
29	26,0	8,0	Toro Brun Saus Glutenfri	32	17,9	35,8	559,4	22,0	0,6	0,1	x
30	27,0	3,0	Semper Maccheroni Glutenfri	500	26,8	53,6	53,6	356,0	1,8	1,0	x
31	28,0	5,0	Schar Salti Kjeks Glutenfri	175	34,9	199,4	199,4	442,0	13,0	5,9	x
32	29,0	2,0	Fria Minibaguette Grov Glutenfri (frossen)	280	67,9	242,5	242,5	305,0	8,2	1,1	x
33	30,0	7,0	Toro Glutenfrie Brownies (melmix)	540	43,5		80,6	398,0	13,0	2,3	x
34	31,0	5,0	Semper FlapJack Tranebær Glutenfri	85	33,0	388,2	388,2	389,0	19,0	6,8	x
35	32,0	2,0	Semper Minibaguetter Glutenfri (langtidsholdbar)	300	56,9	189,7	189,7	272,0	3,5	1,0	x
36	33,0	8,0	Anamma Vegoschnitzel Glutenfri (frossen)	300	53,4	178,0	178,0	230,0	13,0	1,1	x
37	34,0	2,0	Semper Toasty Fiber Bread Glutenfri (frossen)	400	51,5	128,8	128,8	226,0	4,4	0,9	x

Glutenfree products | Gluten containing products | 1. Cereales Both GF and GC | 2. Bread Both GF & GC | 3. Pasta Both GF & GC | 4. Cake Both GF & GC | 5. Snacks Bot

Attachment 1 Picture from database

Tabell 7. Matinntak[a] blant deltagere i Norkost 3 (n=1787), fordelt på kjønn. Spiselig mengde g/d, gjennomsnitt (SD).

Antall	Menn n=862	Kvinner n=925	Totalt n=1787
Brød	**227 (121)**	144 (80)	184 (110)
Kornvarer	45 (62)	35 (41)	40 (52)
Kaker	36 (61)	34 (48)	35 (55)
Poteter	**83 (80)**	50 (57)	66 (71)
Grønnsaker	154 (106)	155 (105)	155 (105)
Frukt, bær	168 (155)	**189 (143)**	178 (149)
Juice, most	114 (178)	100 (149)	107 (164)
Kjøtt, kjøttprodukter.	**181 (126)**	116 (78)	147 (109)
Fisk, fiskeprodukter	**79 (101)**	56 (71)	67 (88)
Egg	28 (42)	23 (33)	25 (37)
Melk, yoghurt	**384 (354)**	249 (237)	314 (306)
Helmelk	29 (102)	24 (71)	26 (87)
Lettmelk	**160 (267)**	87 (162)	122 (222)
Ekstra lett melk	75 (212)	37 (118)	55 (171)
Skummetmelk	60 (186)	39 (126)	49 (158)
Fløte, fløteprodukter	22 (37)	21 (32)	22 (34)
Ost	46 (44)	42 (38)	44 (41)
Smør, margarin, olje	**39 (28)**	24 (19)	31 (25)
Margarin 70-80 % fett	**8 (13)**	5 (7)	6 (10)
Lettmargarin, brelett	**7 (12)**	3 (7)	5 (10)
Smør, bremykt	**7 (13)**	4 (8)	5 (11)
Matolje	3 (5)	2 (4)	2 (5)
Majones, dressing	**11 (18)**	8 (14)	9 (16)
Sukker, søtsaker	**18 (25)**	18 (23)	18 (24)
Kaffe	**591 (508)**	454 (452)	520 (484)
Te	108 (251)	**238 (355)**	175 (316)
Saft/brus	**282 (396)**	202 (329)	240 (365)
Drikkevann	972 (792)	**1150 (738)**	1064 (769)
Øl	**132 (401)**	37 (174)	83 (309)
Vin	44 (124)	46 (114)	45 (119)
Brennevin	4 (21)	2 (12)	3 (17)
Diverse	115 (124)	102 (98)	108 (111)
Snacks	5 (21)	4 (12)	5 (17)

[a] Resultatene er basert på to 24-timers kostintervju.

Uthevet tall markerer statistisk signifikant forskjell i inntak mellom menn og kvinner, testet med Mann-Whitney U-test ($p \leq 0{,}01$).

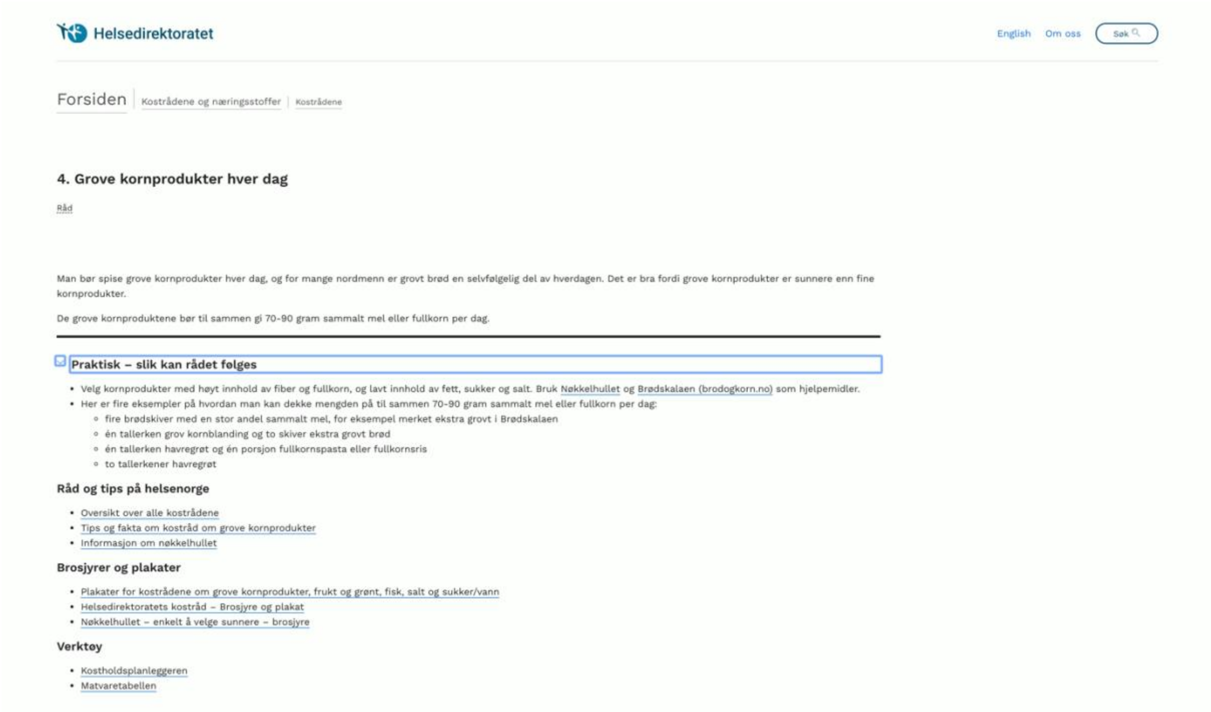
Attachment 2 Numbers on food intake from Norkost 3

Tabell 16. Inntak av energi og næringsstoffer[a] blant deltagere i Norkost 3 (n=1787), fordelt på kjønn[b]. Gjennomsnitt (SD).

Antall	Menn n=862	Kvinner n=925	Totalt n=1787
Mengde per person per dag			
Energi, MJ	**10,9 (3,4)**	8,0 (2,4)	9,4 (3,3)
Protein, g	**112 (37)**	81 (24)	96 (34)
Fett, g	**102 (41)**	75 (29)	88 (38)
mettede fettsyrer, g	**39 (17)**	29 (12)	34 (16)
enumettede fettsyrer, g	**34 (15)**	25 (11)	30 (14)
flerumettede fettsyrer, g	**18 (9)**	13 (7)	16 (8)
Kolesterol, mg	**398 (223)**	301 (173)	347 (205)
Karbohydrat, g	**278 (99)**	205 (72)	240 (93)
tilsatt sukker, g	**48 (43)**	36 (30)	42 (38)
Kostfiber, g	**26 (11)**	22 (8)	24 (10)
Alkohol, g	**10 (22)**	6,3 (14,1)	8,1 (18,5)
Vitamin A, RAE	**1011 (947)**	769 (497)	886 (758)
Vitamin D, µg	**6,7 (5,7)**	4,9 (4,3)	5,8 (5,1)
Vitamin E, mg	**12 (5)**	10 (4)	11 (5)
Tiamin, mg	**1,9 (0,7)**	1,4 (0,5)	1,6 (0,6)
Riboflavin, mg	**2,1 (0,8)**	1,6 (0,6)	1,8 (0,8)
Vitamin B6, mg	**1,9 (0,8)**	1,5 (0,5)	1,7 (0,7)
Vitamin B12, µg	**8,9 (8,0)**	6,0 (3,7)	7,4 (6,3)
Folat, µg	**279 (105)**	231 (86)	254 (98)
Vitamin C, mg	105 (77)	**111 (71)**	108 (74)
Kalsium, mg	**1038 (514)**	811 (364)	920 (457)
Jern, mg	**13 (4)**	9,9 (3,5)	11 (4)
Magnesium, mg	**439 (143)**	346 (110)	391 (135)
Natrium, g	**3,6 (1,4)**	2,5 (1,0)	3,0 (1,3)
Kalium, g	**4,2 (1,3)**	3,4 (1,0)	3,8 (1,2)
Andel av energiinntak (%)			
Protein, E%	18 (4)	18 (4)	18 (4)
Fett, E%	34 (7)	34 (7)	34 (7)
mettede fettsyrer, E%	13 (3)	13 (3)	13 (3)
enumettede fettsyrer, E%	12 (3)	12 (3)	12 (3)
flerumettede fettsyrer, E%	6,3 (2,2)	6,2 (2,3)	6,2 (2,3)
Karbohydrater, E%	43 (8)	44 (8)	44 (8)
tilsatt sukker, E%	7,2 (5,7)	7,4 (5,2)	7,3 (5,4)
Kostfiber, E%	2,0 (0,7)	**2,3 (0,7)**	2,1 (0,7)
Alkohol, E%	**2,5 (5,2)**	2,1 (4,4)	2,3 (4,8)

[a] Resultatene er basert på to 24-timers kostintervju og inkluderer ikke bruk av kosttilskudd.
[b] Uthevet tall markerer statistisk signifikant forskjell i inntak mellom menn og kvinner, testet med Mann-Whitney U-test (p≤0,01).

Attachment 3 Numbers on intake of energy and nutrients from Norkost 3



Helsedirektoratet English Om oss Søk

Forsiden | Kostrådene og næringsstoffer | Kostrådene

4. Grove kornprodukter hver dag

Råd

Man bør spise grove kornprodukter hver dag, og for mange nordmenn er grovt brød en selvfølgelig del av hverdagen. Det er bra fordi grove kornprodukter er sunnere enn fine kornprodukter.

De grove kornproduktene bør til sammen gi 70-90 gram sammalt mel eller fullkorn per dag.

Praktisk – slik kan rådet følges

- Velg kornprodukter med høyt innhold av fiber og fullkorn, og lavt innhold av fett, sukker og salt. Bruk Nøkkelhullet og Brødskalaen (brodogkorn.no) som hjelpemidler.
- Her er fire eksempler på hvordan man kan dekke mengden på til sammen 70-90 gram sammalt mel eller fullkorn per dag:
  - fire brødskiver med en stor andel sammalt mel, for eksempel merket ekstra grovt i Brødskalaen
  - én tallerken grov kornblanding og to skiver ekstra grovt brød
  - én tallerken havregrøt og én porsjon fullkornspasta eller fullkornsris
  - to tallerkener havregrøt

Råd og tips på helsenorge

- Oversikt over alle kostrådene
- Tips og fakta om kostråd om grove kornprodukter
- Informasjon om nøkkelhullet

Brosjyrer og plakater

- Plakater for kostrådene om grove kornprodukter, frukt og grønt, fisk, salt og sukker/vann
- Helsedirektoratets kostråd – Brosjyre og plakat
- Nøkkelhullet – enkelt å velge sunnere – brosjyre

Verktøy

- Kostholdsplanleggeren
- Matvaretabellen

Attachment 4 Recommendations on how to eat enough wholegrains