Are gluten-free products a healthier alternative?

A pilot study on nutrients and heavy metals

Nordic Council of Ministers

Are gluten-free products a healthier alternative?

A pilot study on nutrients and heavy metals

Helena Pastell
Barbro Kollander
Liisa Valsta
Janne Järvinen

In cooperaton with

Cecilia Axelsson, Monica Hauger Carlsen, Ellen Kielland, Heli Reinivuo, Tiina Sirkjärvi, Veronica Öhrvik and Jorån Østerholt Dalane

Contents

Abbreviations 5

Preface 6

Acknowledgements 7

Executive summary 8

A definition of a gluten-free product 10

1. Background 11

1.1. The market for gluten-free products 12

1.2 Nutrients and heavy metals in gluten-free products 13

1.3 Collaboration with a Nordic Working Group for Food Safety & Consumer Information (NMF) 14

1.4 A brief overview of the situation for gluten-free products in Finland, Norway and Sweden: Food composition databases (FCDBs) and product consumption 14

2. Objectives 17

3. Project members and activities 18

3.1. Participants 18

3.2 Activities of the project 19

4. Sampling 20

4.1. Gluten-free products 20

4.2 Gluten-containing products 23

5. Laboratory analysis 24

5.1 Methods of energy nutrients, and ash and dry matter analysis 24

5.2 Minerals and heavy metals (essential and non-essential elements) 25

6. Statistical methods 27

6.1 Wilcoxon's Man-Whitney rank sum test 27

6.2 Boxplots 27

6.3 Principal component analysis (PCA) 27

6.3.1 Data standardisation 28

6.3.2 PCA with the R program 28

6.3.3 Factor scores 29

7. Results and Discussion 30

7.1 Wilcoxon's Mann-Whitney rank sum test 30

7.2 Boxplots 33

7.3 Principal component analysis (PCA) 38

7.3.1.1. PCA and factor score analysis of Category 1 ('Flours and flakes') 45

7.3.1 Category 1: Flours and flakes 41

7.3.2 Category 4: Breads and wraps 49

7.3.2.1. PCA and factor score analysis of Category 4 ('Breads and wraps') 53

7.4 Descriptive analysis 55
7.4.1 Category 2: Cereal flakes 56
7.4.2 Category 3: Muesli and granola 56
7.4.3 Category 5: Waffle mix and cookies 57
7.4.4 Sugars 57
7.4.5 Dietary fibre 57
7.4.6 Chemical elements not included in PCA 59

8. Conclusions 60

References 61

Nordic summaries 64
Suomenkielinen yhteenveto: Ovatko gluteenittomat tuotteet terveellisempi vaihtoehto? 64
Norsk sammendrag: Er glutenfrie produkter et sunnere alternativ? 66
Svensk sammanfattning "Är glutenfria produkter ett hälsosammare alternativ?" 68

Appendix 1. Product information 70

Appendix 2. Values for major nutrients and salt, in fresh weights 76

Appendix 3. Values for essential and non-essential elements, in fresh weights 90

Appendix 4. PCA and factor score analysis loadings and result tables 101

Appendix 5. Contact persons, addresses and contact information 104

About this publication 106

Abbreviations

DF	Dietary fibre
DW	Dry weight
EFSA	European Food Safety Authority
Evira	Finnish Food Safety Authority (FFA, since 1 Jan. 2019)
FCDB	Food composition database
FFA	Finnish Food Authority (Ruokavirasto)
FW	Fresh weight
HPLC	High-performance liquid chromatography
HR-ICP-MS	High-resolution Inductively Coupled Plasma Mass Spectrometry
IDF	Insoluble dietary fibre (polysaccharides)
LOD	Limit of detection
LOQ	Limit of quantification
MU	Measurement uncertainty
NCM	Nordic Council of Ministers
NFSA	Norwegian Food Safety Authority (Mattilsynet)
NKMT	Nordic Working Group for Diet, Food & Toxicology
NMF	Nordic Working Group for Food Safety & Consumer Information
NMKL	Nordic Committee on Food Analysis
NMR	Nuclear magnetic resonance
NordCoLa	Nordic Food Composition Data for Labelling
PCA	Principal component analysis
RINTDF	Rapid integrated total dietary fibre assay procedure
SFA	Swedish Food Agency
SDFP	Water-soluble dietary fibre polysaccharides
SDFS	Water-soluble dietary fibre oligosaccharides (3–10 sugar units)
THL	Terveyden ja hyvinvoinnin laitos (Finnish Institute for Health and Welfare)
UIO	University of Oslo

Preface

This report describes the work that was carried out in the project 'Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals' between 2017 and 2020. The majority of the people involved in this project have participated in Nordic collaboration projects, starting from the beginning of the Nordic Food Analysis Network in 2012. The same group has been coordinating the chemical food analysis in the Nordic countries and Estonia in several other projects. The current project had participants from Finland, Norway and Sweden, and it started in collaboration with the Nordic Working Group for Food Safety & Consumer Information (NMF) project 'Nordisk project om control af glutenfri produkter' (in Eng.: 'The Nordic project regarding the control of gluten-free products'). The two projects shared sample lists but then continued to operate according to the goals of their own projects.

The primary objective of this project was to improve knowledge on the content of important nutrients and heavy metals in gluten-free products. Some general results are discussed in the report, but no attempt was made to cover a full evaluation. Generated data may be used for, for example, risk and benefit analysis, dietary surveys and product development. A secondary objective was to further improve Nordic collaboration regarding food composition data by complementing the Nordic Food Composition Data for Labelling (NordCoLa) project carried out between 2018 and 2020), focusing on nutrients only.

Acknowledgements

This work, carried out in the project 'Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals', was funded by the Nordic Council of Ministers' Nordic Working Group for Diet, Food & Toxicology (NKMT). The Nordic Working Group for Food Safety & Consumer Information (NMF) project is acknowledged for sharing the product list, samples and the results of the gluten analysis.

The work of the group members listed below, who contributed to the work and commented on the draft report, is highly appreciated:

Helena Pastell, Janne Järvinen	FFA, Finland
Jorån Østerholt Dalane, Ellen Kielland	NFSA, Norway
Cecilia Axelsson, Barbro Kollander, Veronica Öhrvik	SFA, Sweden
Tiina Sirkjärvi, Heli Reinivuo, Liisa Valsta	THL, Finland
Monica Hauger Carlsen	UIO, Norway

Also, the people who assisted in purchasing and preparing the samples for analysis are acknowledged: Erika Åström and Emma Eriksson of the Swedish Food Agency, Sweden.

Executive summary

This report describes the work that was carried out in the project 'Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals' between 2017 and 2020. The primary aim was to improve knowledge on the content of important nutrients and heavy metals in gluten-free products.

Sampling of gluten-free products was performed in Finland, Norway and Sweden. Nutrients and heavy metals were analysed in 37 gluten-free products, including flours, cereal flakes, muesli, bread and cookies. The nutrients determined were: moisture, ash, nitrogen, fat, starch, sugars and dietary fibre. The analysed essential elements were: calcium, cobalt, copper, chromium, iron, iodine, potassium, magnesium, manganese, molybdenum, phosphorus, selenium and zinc. Furthermore, arsenic, silver, aluminium, cadmium, mercury, nickel and lead were non-essential elements that were determined.

In addition to the gluten-free products, conventional foods suitable for similar uses, the majority of which naturally contain gluten, were selected for comparisons. Gluten-containing foods were either branded products from online stores or generic products from food composition databases (FCDBs). Altogether 136 gluten-containing products were selected for comparisons, but the information on nutrients and heavy metals was not as extensive as it was for the sampled gluten-free products. For branded products, only mandatory labelling information was available (energy, fat, saturated fatty acids, total carbohydrates, sugars, protein and salt). For generic foods, more data was available but values for some individual sugars, separate dietary fibre fractions and some elements were missing.

The nutrient and heavy-metal values of the gluten-free products were compared with those of gluten-containing ('conventional') products by using principal component analysis (PCA). For PCA, all results were converted into dry weights to facilitate the comparison of different products. The products were also divided into five categories based roughly on their common use, processing level and energy nutrient content in order to better examine the differences in detail between gluten-free and gluten-containing products. The categories were: (1) flours and flakes (raw materials); (2) cereal flakes (processed, multiple ingredients); (3) muesli and granola; (4) breads and wraps; and (5) waffle mix and cookies. Three products were excluded from the PCA analyses because they differed too much from the other data and did not represent the selected group. In addition, because of the missing data, individual sugars and dietary fibre fractions were not utilised in PCAs. Iodine, selenium, arsenic, silver and mercury also had to be excluded from PCA due to too many missing values.

The results from this project are based on a limited number of samples and may not be generalised to all gluten-free products. However, statistically significant differences were found between gluten-free and gluten-containing product groups. Some main conclusions can be drawn, and strategical proposals suggested on the basis of the data:

- Gluten-free products are a heterogenous group based on their nutrient composition, including basic foods (derivatives of single raw commodities) and composite foods (consisting of several ingredients). In composite foods, the main differences were based on ingredients other than cereal ingredients, such as milk powder, fats or fortification agents (e.g. iron).
- The gluten-free products contained significantly less protein, copper, potassium, phosphorus, zinc and manganese than the included gluten-containing products.
- The contents of starch and chromium were significantly higher in the gluten-free products than in the gluten-containing products.
- The levels of cadmium were similar in the gluten-free and gluten-containing products.
- The gluten-free products contained significantly higher levels of nickel and lead compared with the gluten-containing products. Most of the lead values were well below the EU maximum level (20 µg Pb/100 g for cereals), but there are currently no maximum levels for nickel.
- In the product development of gluten-free products, attention must be paid to the nutritional content and non-essential elements of the gluten-free ingredients in new products.

Are gluten-free products a healthier alternative? Considering the nutritional composition, gluten-free products are not healthier compared to similar gluten-containing products. In addition, the content of some heavy metals is higher in the gluten-free products studied.

The nutritional values of the gluten-free products analysed in the project will be added to FCDBs. For gluten-free raw materials in particular, the coverage of the Nordic FCDBs can be considered better after this project. However, since the non-essential elements such as As, Ag and Hg, and other non-wanted substances like mycotoxins, dioxin etc., are mostly not included in the Nordic FCDBs, there will still be a lack of data for risk–benefit assessment. In order to develop a long-term diet that sustains health, it is important to fill these gaps. Nordic FCDBs contain partially different nutrients in different units, and some nutrients are even calculated based on different factors. In particular, there is still a lack of results for individual sugars, dietary fibre fractions, I and Se. The need for harmonisation was already discussed in a previous Nordic co-operation project (the NordCoLa project) and is still seen as a factor that would facilitate co-operation in the future. Working together with the other Nordic countries is considered beneficial as the resources are shared and the results are for everyone to use.

A definition of a gluten-free product

Gluten-free products cannot contain more than 20 mg/kg of gluten according to EU standards. Products labelled as *very low gluten* contain gluten over 20 mg/kg but not more than 100 mg/kg (Codex Stan 118-1979; (EU) N:o 828/2014). The common cereals wheat, rye and barley contain gluten (approximately 30–90 g/kg; Schalk et al., 2017) and are therefore unsuitable for people with celiac disease. Gluten-free cereals are millet, corn, rice, teff, tapioca and gluten-free oats.[1] Furthermore, the pseudo-cereals amaranth, quinoa and buckwheat do not contain gluten and thus can be consumed as a part of gluten-free diet. *Gluten-free products* hereafter refers to products labelled as *gluten free* which are intended to be used as substitutes for gluten-containing products, unless otherwise stated. Note that this definition will place products like rice flour, which is labelled as *gluten free,* in the gluten-free category while tapioca flour, which is inherently gluten free but not labelled as *gluten free*, in the gluten-containing group.

1. Producing gluten-free oats requires avoiding cross-contamination with wheat, rye and barley (Finnish Coeliac Society, 2020).

1. Background

Increased wholegrain consumption is one of six reference visions for 2021 in the 'Nordic Plan of Action on better health and quality of life through diet and physical activity' (Nordic Council of Ministers [NCM], 2006). However, individuals with celiac disease cannot eat wholegrain products (except for pure oats) but may replace them with gluten-free alternatives. In the last Swedish national food survey, 'Riksmaten Adolescents 2016–17', the median intake of bread and pasta among adolescents were 100 g and 50 g per day, respectively (Warensjö Lemming et al., 2018). The study does not differentiate between gluten-containing and gluten-free products, thus it is not possible to specifically estimate the intake of gluten-free products. However, since bread and pasta account for a substantial part of the daily intake of grain products, substituting this intake with gluten-free products will therefore lead to a high intake of gluten-free products. As bread, pasta and also cereals significantly contribute to nutrient intake in the Nordic countries (see Table 1), it is very important that the gluten-free alternatives also include the valuable nutrients. In order to achieve sustainable health, it is of utmost importance to verify that substitution with gluten-free products neither contributes to a lower intake of nutrients nor to a higher intake of heavy metals.

Table 1. The contribution of grain products (bread, cereals, gruel, porridge, semolina and pasta) to the daily intake (%) of some nutrients and heavy metals in the most recent dietary surveys in Finland, Norway and Sweden.

	Daily intake in %*												
	Energy	*Fibre*	*Protein*	*Sugars*	*Fe*	*Mg*	*Na*	*Zn*	*As*	*Cd*	*Pb*	*Hg*	*Ni*
FinDiet 2012[1],**	31	56	23	17¤	43	30	33	33					
FinDiet 2017[2],**	29	52	22	20¤	35	28	28	29					
Finnish Food Authority 2020[3],**									14	31	16	1	20
Norkost 3[4]	27	53	22	4	37	31	24	-					
Riks-maten Adults 2010–2011[3]	17	39	13	17	25	21	16	16					
Riks-maten Adolescents 2016–2017[5]	17	35	15	20	25	19	18	15					
Swedish Market Basket Survey 2015[6]	27	46	19	6	33	-	22	25	4	40	17	7	33

1 Helldán et al., 2013
2 Valsta et al., 2018
3 Suomi et al., 2020
4 Totland et al., 2012
5 Warensjö Lemming et al., 2018
6 Swedish Food Agency (2017) – data is based on per capita consumption and is therefore not completely comparable with the other dietary surveys
* Food classification may differ in different countries, causing not totally comparable proportions
** Average contribution of females and males
¤ Expressed as sucrose content

1.1. The market for gluten-free products

During the last decade there has been an increased demand for and supply of gluten-free products in the Nordic and global markets (ICA, 2018; Svenska Dagbladet, 2017). The increase is expected to continue at a rapid pace over the coming years (Allied Market Research, 2020; Reportsanddata, 2019; MarketsandMarkets, 2020). The increase applies to substitute products, such as gluten-free pasta and bread, but there has also been an increase in new and alternative products, such as natural gluten-free products (e.g. pasta made from beans and lentils instead of wheat flour) (Swedish Food Agency [SFA], 2020).

The prevalence of celiac disease in the Nordic countries is estimated to be 1–2% (Dubé et al., 2005). In addition to individuals with celiac disease, an increasing number of Nordic inhabitants choose to follow a gluten-free diet due to 'health concerns'. In Finland, for example, the volume of gluten-free marketed products per

capita has increased 150% from 2010 to 2020 (Euromonitor market research, 2020).

1.2 Nutrients and heavy metals in gluten-free products

Although the market for gluten-free products has increased rapidly, there is a lack of analytical nutrient data on gluten-free products in the Nordic (and other) food composition databases (FCDBs), which may result in, for example, associated errors of energy and nutrient intake estimates. Gluten-free alternatives are often made of wheat or corn starch. To improve the fibre content in the healthier alternatives, fibres – for example, from apple and sugar beet – may be added. Accordingly, the dietary fibre (DF) profiles, as well as the amount of minerals, might differ substantially from normal cereal-based products. Examination of the Nordic FCDBs reveals that only a small amount of analytical data on gluten-free foods is available and that it is usually produced by using DF methods that do not include oligosaccharides. Thus, the existing data is not correct according to the EU definition of *dietary fibre* (Codex Alimentarius, 2009). As cereals are a major contributor of dietary fibre (see Table 1), fibre content in gluten-free products is of great interest and must be presented correctly. Currently, only a few labs analyse fibre according to the EU definition, one of them is the Finnish Food Authority (FFA), who use the latest method, AOAC 2017.16 (McCleary et al., 2015).

A minor study performed at the SFA in 2016 compared fibre-rich gluten-free bread and traditional fibre-rich bread and found that gluten-free bread contained significantly lower amounts of zinc (see Table 2) and protein, whereas the fat content was more than twice higher. Milling is known to reduce, for example, zinc and iron concentrations in cereals (Fennema, 1996). Thus, gluten-free products are often fortified with iron and also vitamin B. Vitamin analyses were not included in this pilot study due to the limited budget and the high analytical cost of vitamins. In addition, the interpretation of the results of vitamin content analysis in gluten-free products is not straightforward as some products may be fortified with vitamins.

Published data on heavy metals in gluten-free products are, to our knowledge, scarce or missing. The general opinion seems to be that replacing wholegrain bread with gluten-free fibre-rich alternatives may be beneficial since the cereal husk contributes to a higher heavy metal intake (Jorhem et al., 2013, 2015). However, a minor study comparing fibre-rich gluten-free bread and traditional fibre-rich bread found that the gluten-free bread contained significantly higher amounts of lead and arsenic (see Table 2). Cadmium was higher in 50% of the dark gluten-free breads and so was nickel. In 2015, EFSA concluded that a high intake of nickel was a health concern and made a call for increased monitoring.

Table 2. Minerals and heavy metals (essential and non-essential elements) in fibre-rich (dark) gluten-free breads compared with comparable breads containing gluten (SFA, 2020).

Notes: *Arsenic is a metalloid but is generally included in *heavy metals*

	Gluten-free breads (n = 9)	**Breads with gluten** (n = 14)	**P**
Heavy metals			
As* (µg/kg)	17 ± 6	6 ± 2	0.047
Cd (µg/kg)	37 ± 33	32 ± 20	0.925
Pb (µg/kg)	20 ± 7	7 ± 6	<0.001
Minerals			
Fe (mg/100g)	3.8 ± 2.6	2.2 ± 0.3	0.270
Na (g/100g)	0.71 ± 0.14	0.65 ± 0.10	0.508
Ni (mg/kg)	0.48 ± 0.35	0.21 ± 0.12	0.055
Se (µg/100g)	4.0 ± 5.0	3.3 ± 2.2	0.571
Zn (mg/100g)	1.2 ± 1.2	2.0 ± 0.3	0.025

1.3 Collaboration with a Nordic Working Group for Food Safety & Consumer Information (NMF)

In parallel with the current project, a project funded by the Nordic Working Group for Diet, Food & Toxicology (NKMT) on gluten content in products labelled *gluten free* was carried out by NMF. To achieve synergies between both projects, sampling matters and the choice of products were discussed in common.

1.4 A brief overview of the situation for gluten-free products in Finland, Norway and Sweden: Food composition databases (FCDBs) and product consumption

It has been estimated that around 1–2% of citizens in Finland, Norway and Sweden have celiac disease, with most of the cases going undiagnosed (Finnish Coeliac Society, 2020; Norwegian Celiac Society, 2020; Browaldh et al., 2014; Sjögren, 2020). In Norway it is estimated that an additional 7–8% of the population do not tolerate gluten or other substances in wheat (Norwegian Celiac Society, 2020). The incidence of diagnosed celiac disease differs between age groups, and in Sweden it is highest (3%) amongst people born between 1984 and 1996, which could be explained by changes in infant feeding during this period (Myléus et al., 2009). At that time in Sweden, it was recommended to only start eating grain products at the age of six months. The current recommendation is that the use of cereals be gradually started as 'tasting portions' at the age of four to six months. Switching to this recommendation has reduced the incidence of celiac disease in Swedish children (Popp & Mäki, 2019).

The FCDBs in all three countries have a limited range of food items representing

products labelled *gluten free*. However, all the databases contain a wider range of cereal food items that are naturally gluten free.

Finland

Finland's gluten-free market size has increased 150% in volume per capita during the last 10 years. In 2010, around 600 grams of products in the 'Free from gluten' category was consumed per capita when, in 2020, the consumption in the same category reached 1500 grams per capita according to Euromonitor market research. This increase only considered products that were marketed as *gluten free*, like bread, biscuits, breakfast cereals and pasta. The biggest market increase was seen in gluten-free pasta and bread. The volume share of gluten-free products in their food category has increased from 2010 to 2020 (e.g. bread increased from 0.8% to 2.4%, pasta from 1.3% to 3.7% and breakfast cereals from 2.9% to 4.9%) (Euromonitor Market research, 2020).

In 2020 the Finnish Fineli FCDB contained around 230 gluten-free cereal products, such as: flours, grains or flakes from rice, buckwheat, corn, quinoa, amaranth, millet, potato, and potato starch, gluten-free oats, psyllium, sugar beet flakes, tapioca, breakfast cereals, porridges, breads, cakes, biscuits, and savoury and sweet baked goods.

Norway

The Norwegian Food Composition Table contains a small selection of labelled gluten-free products, including gluten-free flour / flour mix, crispbread, bread, cake mix, pasta, waffles and sweet buns. Both flour and pasta products are represented with products made of different sorts of ingredients. Several brands are represented.

During 2017–2018, the Norwegian Food Safety Authority (NFSA) analysed the nutrient content of ten products containing rice. The selection of products in the project was made based on bestsellers (either products or producers). The nutrient values for most of the gluten-free products in the food composition table come from this project. The nutrient information for the remaining gluten-free products are compiled from either the declared nutrient labels or product ingredients lists, or calculated from recipes.

The selection and the representation of the gluten-free foods available on the market is still limited in the food composition table and should be extended in the years to come, starting with the contribution of this work.

Sweden

The Swedish Food Composition Database contains a total of 17 food items labelled as *gluten free*, mostly bread and pasta but also a few flakes, biscuits and cakes. Data for 15 of the food items come from chemical analysis and two are recalculated (the data for cooked pasta is calculated from the data of uncooked pasta). Of the 17 food items, 15 have nutritional values that come from analyses made in 2007 and two from analyses made in 2016. In 2007, only one product per food item was analysed, while the two most recent data sets from 2016, concerning gluten-free white and dark bread, were composite samples that included several different products and brands based on sales statistics. Given the product development in the gluten-free market in the last decade and the fact that most analytical values in the database only represent single food items, it is conceivable that the values for most of the foods do not correspond to those of today's products.

2. Objectives

The objectives of this project were:

- To identify products of interest for following laboratory analyses:
  - Fibre (*n* = 20)
  - Nutrients (excluding vitamins) and heavy metals (*n* = 40)
- To analyse the following nutritional factors of the selected products:
  - Total DF, water-soluble dietary fibre (SDF) and water-insoluble dietary fibre (IDF) were analysed at the FFA, using method AOAC 2011.25 according to the EU definition
  - Minerals (essential elements: Ca, Co, Cr, Cu, Fe, I, K, Mg, Mn, Mo, Na, Ni, P, Se, Zn) and heavy metals (non-essential elements: Ag, Al, As, Cd, Hg, Ni, Pb) were analysed at ALS Scandinavia AB in Luleå, Sweden
  - Other nutrients (protein/nitrogen, fat, sugars, starch, water, ash) were analysed at a commercial laboratory
- To compare products with existing data on comparable products containing gluten
- To evaluate results using principal component analysis (PCA)
- To summarise the results
- To disseminate and publish the results with TemaNord and in national FCDBs

3. Project members and activities

3.1. Participants

The institutes and members who participated in the project 'Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals' are listed in Tables 3 and 4.

Table 3. Partner institutions in the project.

Institution	Country
Finnish Food Authority (FFA) aka Ruokavirasto, www.ruokavirasto.fi	Finland
Finnish Institute for Health and Welfare (THL), Public Health Promotion Unit, www.thl.fi	Finland
Swedish Food Agency (SFA, the former National Food Agency), www.slv.se	Sweden
Norwegian Food Safety Authority (NFSA), www.mattilsynet.no	Norway
University of Oslo (UIO), www.uio.no	Norway

Table 4. The members of the project and their roles.

Members	Description of role	Institution
Helena Pastell, Senior Researcher, PhD	Project leader: responsible for the flow of samples, processing of laboratory results, report writing	FFA
Janne Järvinen, Researcher, MSc	Statistical analysis, report writing	
Tiina Sirkjärvi, Researcher MSc	Data collecting, commenting on the report	THL
Heli Reinivuo, Senior Nutrition Specialist, MSc	Data collecting, commenting on the report	
Liisa Valsta, Research Manager, Adjunct Professor, PhD	Report writing, the evaluation of PCAs	
Cecilia Axelsson, Risk and Benefit Assessor, MSc	Data collecting, commenting on the report	SFA
Barbro Kollander, Senior Chemist, PhD	Flow of samples, the evaluation of laboratory results for elements, report writing	
Veronica Öhrvik, Senior Advisor, PhD	Project application, statistical analysis, commenting on the report	
Jorån Østerholt Dalane, Senior Advisor, MSc	Data collecting, commenting on the report	NFSA
Ellen Kielland, Senior Advisor, MSc	Data collecting	
Monica Hauger Carlsen, Associate Professor, PhD	Data collecting, commenting on and editing the report	UIO

3.2 Activities of the project

The project began in 2018 with sampling, planned jointly with the Nordic Working Group for Food Safety & Consumer Information (NMF) project. Sampling issues were handled via email, as was logistical planning related to laboratory analyses. Samples were analysed during 2018–2019, but otherwise the progress in the project was limited for scheduling reasons at that time. In 2020, the project was actively underway. The project group met 10 times in teleconferences to evaluate the large amount of analytical data obtained in the project. Between the meetings, the group worked independently on result data and the project report. The last teleconference was held in early 2021, when a common line was agreed upon regarding communicating the results of the project by the time the report is published.

4. Sampling

The sampling of gluten-free products was performed in Finland, Norway and Sweden. Products were obtained in part from the NMF project and in part purchased from retail stores. After sampling, the products were sent to the FFA and/or to a private laboratory (ALS Scandinavia AB, Luleå, Sweden) for analysis. No sampling of gluten-containing products was performed. Instead, product information was collected from the Internet and from the FCDBs of Finland, Norway and Sweden.

4.1. Gluten-free products

The NMF project provided a list of 176 gluten-free products chosen from Denmark, Finland, Norway and Sweden. The gluten content of all the products labelled *gluten-free* was analysed in the NMF project. The products were divided into four categories in the NMF project: (1) raw material; (2) flour mixtures; (3) breakfast products; and (4) breads, cakes etc. The members of the NKMT project 'Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals' chose altogether 40 gluten-free products from the list (covering all the original categories) for a more thorough analysis of nutrients (see Table 5). The plan was that the samplers in the NMF project would each take twice the number of the 40 products chosen and donate the extra ones for the use of the NKMT project. Due to schedule problems, only Finnish products were obtained as planned from the joint sampling. The missing Norwegian and Swedish products were purchased separately by the project members.

Table 5. The gluten-free products selected for the analysis of nutrients, grouped according to the NMF-project needs.

NMF product category	Product description	Sampling country	Availability	County of origin
Raw material	Gluten-free bun flour mix, Viljatuote	FI	FI	FI
	Gluten-free baking flour with oats, Provena	FI	FI, SE	FI
	Corn flour, Spielberger	FI	FI	IT
	Buckwheat flour, Raisio	FI	FI	FI
	Wholegrain oat flour, gluten free, Viljatuote	FI	FI	FI
	Coarse buckwheat flour, Viljatuote	FI	FI	EU
	Rice flour, Viljatuote	FI	FI	IT
	Teff flour	FI	FI	NO
	Sugar beet flakes, Fibrex	FI	FI, SE, NO	CH
	Maize groats, Risenta	FI	FI, SE	IT
	Buckwheat flour, Risenta	SE	FI, SE	n.k.
Flour mixtures	Gluten-free waffle mix, TORO	NO	NO	n.k.
	Gluten-free flour mix, coarse, TORO	NO	NO	n.k.
	Gluten-free oat bread mix, TORO	NO	NO	n.k.
	Flour mix 'Finmix', Semper	SE	FI, SE, NO	n.k.
	Flour mix, Finax	SE	FI, SE, NO	SE
Breakfast products	Rice flakes, Myllyn Paras	FI	FI	FI
	Gluten-free cereal flakes, Schär	NO	SE, NO	n.k.
	Gluten-free Corn Flakes, Schär	NO	SE, NO	n.k.
	Gluten-free special flakes, fortified, Semper	SE	FI, SE, NO	IT
	Gluten-free muesli with fruit, Finax	SE	FI, SE, NO	SE
	Gluten-free muesli with raisins and figs, Risenta	SE	FI, SE	n.k.
	Paulun's gluten-free granola with blueberries, rhubarb, cardamom and cinnamon, Orkla Foods	SE	FI, SE	n.k.

NMF product category	Product description	Sampling country	Availability	County of origin
Breads, cakes etc.	Gluten-free crispbread, Pirkka	FI	FI	RO
	Millet-corn cake, Bio Zentrale	FI	FI	non-EU
	Karelian pasty with rice filling, Vuohelan herkku	FI	FI	FI
	Gluten-free buckwheat bread, Suloiset	FI	FI	FI
	Gluten-free crackers, Schär	NO*	FI, SE, NO	DE
	Gluten-free ciabatta, Schär	NO*	FI, SE, NO	DE
	Gluten-free wraps, Schär	NO*	SE, NO	IT
	Gluten free wraps, Bfree	NO*	SE, NO	US
	Gluten-free chocolate-chip cookies, Schär	NO*	FI, SE, NO	DE
	Gluten-free dark loaf with linseed, Fria Bröd	SE	SE, NO	SE
	Gluten-free crispbread with chia seeds, Semper	SE	SE, NO	SE
	Gluten-free sourdough bread, Schär	SE	SE, NO	IT
	Gluten-free sourdough bread, Friends of Adam	SE	SE	n.k.
	Gluten-free crispbread with sesame seeds and sea salt, Wasa	SE	FI, SE, NO	n.k.

*The product was selected by Norway but purchased from Finland.
CH = Switzerland, DE = Germany, FI = Finland, IT = Italy, NO = Norway, RO = Romania, SE = Sweden, US = the United States, non-EU = countries that are not a member of the European Union, n.k. = not known

The product grouping of the NMF project was not optimal for this project, and thus the products were re-grouped. It was hypothesised that different types of products contain remarkably different amounts of, for example, fat, sugars and DF, and the use of products in a diet is different. In order to examine the differences between gluten-free and gluten-containing products in better detail, they were divided into the five following categories (with possible group-specific features in parentheses):

1. Flours and flakes (raw materials)
2. Cereal flakes (processed, multiple ingredients)
3. Muesli and granola (processed, multiple ingredients, high in sugars)
4. Breads and wraps (processed, multiple ingredients, high in DF)
5. Waffle mix and cookies (processed, multiple ingredients, high in sugars and fat)

All the products (gluten-free and gluten-containing products) in the presented five categories are listed in Appendix 1 (Tables 1.1–1.5).

4.2 Gluten-containing products

A wide selection of products containing gluten were chosen to enable the comparison of the gluten-free diet with the conventional diet. Gluten-containing products were mainly composed of traditional cereals grown in the Nordic countries and Europe: wheat, oats, rye and barley. The gluten-containing products were selected in order to have a similar purpose of use as that of the project's gluten-free products (see Table 5). Nutritional information was collected from two types of products: branded products that were searched from online stores and generic products whose data was obtained from national FCDBs.

The branded products only contained the compulsory nutritional information detailed on the packages and thus only information on energy, fat, saturated fatty acids, total carbohydrates, sugars, protein and salt content were available. The food components of generic products found from the Finnish, Norwegian and Swedish FCDBs were much more versatile. However, some of the chemical elements determined in the gluten-free products were not available in all FCDBs for the chosen generic products. Furthermore, DF fractions (water-insoluble polysaccharides, water-soluble polysaccharides and oligosaccharides) and some individual sugars were not found in all FCDBs. Due to the lack of data on gluten-containing products, some of the nutrients had to be excluded from statistical comparisons.

5. Laboratory analysis

5.1 Methods of energy nutrients, and ash and dry matter analysis

The DF content of the samples was determined at the laboratory of the FFA, using a combination of the enzymatic-gravimetric method and the high-performance liquid chromatography (HPLC) method. In the objectives (Chapter 2), the use of the AOAC 2011.25 method in DF analysis was mentioned. However, after writing the project application in 2018, the DF method was updated. The latest version, AOAC 2017.16 (the rapid integrated total dietary fibre assay procedure [RINTDF]; McCleary et al., 2015), was verified and accredited at the FFA and gluten-free products are now analysed using this version of the method. The principle of the methods AOAC 2011.25 and AOAC 2017.16 is the same; the main differences between the methods are the hydrolysis time used to remove starch, the enzymes used and the new HPLC column for analysing oligosaccharides. In both methods, starch and protein are enzymatically removed and the different DF fractions (water-insoluble polysaccharides, water-soluble polysaccharides and oligosaccharides) are separated based on their solubility and size. Polysaccharides are dried, weighed and the results are corrected by the amount of residual protein and ash. Polysaccharides are analysed using HPLC. The total DF content is the sum of the fractions mentioned above (McCleary, 2019; Megazyme, 2020).

Ash, dry matter / moisture, fat, protein, starch and sugars (fructose, galactose, glucose, sucrose, maltose and lactose) were analysed by ALS (Prague, Czech Republic) with accredited methods. The methods used are presented in Table 6.

Table 6. Method descriptions for the analysis of energy nutrients, ash and dry matter. The limits of quantification (LOQ; LOQ = 10*std for blank) in g/100 g and measurement uncertainty (MU; MU = 95%, *k* = 2) in per cent.

Note: LOQ = The limit of quantification

Analyte	Method	Measurement uncertainty	LOQ (g/100g)
Ash	Gravimetric method	3%	0.060
Dry matter	Gravimetric method; 105oC	1%	0.10
Moisture	Calculated from dry matter content	1%	0.10
Fat	NMR	5%	0.10
Protein	Nitrogen by the Dumas method; protein calculated from the measured value	5%	0.300
Starch	Polarimetric method	6%	2.2
Sugar	Ion chromatography with electrochemical detection	20%	0.05
Dietary fibre	AOAC 2017.16; the enzymatic-gravimetric method + the HPLC method	21%	0.2*

*In dietary fibre analysis for oligosaccharides only (HPLC), LOQ = 6*std for blank.

5.2 Minerals and heavy metals (essential and non-essential elements)

The analysis of total concentrations of essential and non-essential elements in the samples were performed by ALS Scandinavia AB (Luleå, Sweden) using high-resolution inductively coupled plasma mass spectrometry (HR-ICP-MS). The method is based on the accredited method that ALS Scandinavia AB use in their routine work for the analysis of biological matrices (Engström, 2004; Rodushkin, 2008). The method detection limits (defined as three times the standard deviation of analyte concentrations, measured in a set of preparation blanks) are presented in Table 7, together with the measurement uncertainty. The laboratory routinely participates in proficiency tests, and both certified and in-house reference materials are routinely analysed and evaluated together with the samples for careful control of the quality of the analyses.

Table 7. The limits of detection (LOD; LOD = 3*std for blank, *n* = 4) in µg/kg and measurement uncertainty (MU; MU = 95%, *k* = 2) in per cent for essential and non-essential elements, measured by ALS Scandinavia AB (Luleå, Sweden) using HR-ICP-MS.

Essential elements	MU (%)	LOD (µg/kg*)	Non-essential elements	MU (%)	LOD (µg/kg*)
Ca	21	750	**As**	28	0.6
Co	12	0.3	**Ag**	22	0.1
Cr	19	4	**Al**	24	54
Cu	19	2	**Cd**	21	0.6
Fe	22	80	**Hg**	-	0.4
I	-	<80	**Ni**	23	2
K	22	360	**Pb**	19	0.1
Mg	3	80			
Mn	21	2			
Mo	18	8			
Na	21	550			
P	21	60			
Se	-	50			
Zn	21	70			

* 1 µg/kg = 0.1 µg/100g = 0.0001 mg/100g

6. Statistical methods

Statistical methods were used to compare gluten-free and gluten-containing products. The aim was to find out whether the products differed in terms of their content of nutrients and non-essential elements.

6.1 Wilcoxon's Man-Whitney rank sum test

Data was not normally distributed, so the non-parametric Wilcoxon's Mann-Whitney rank sum test was used to compare the content of nutrients and heavy metals of gluten-free and gluten-containing products.

6.2 Boxplots

To visualise the differences between the nutritional values of gluten-free and gluten-containing products, boxplot figures were drawn. The data in these figures represents all the subgroups (from 1 to 5) presented previously (Section 4.1). The aim of these figures was to see whether there is a statistically significant difference between the contents of nutrients and non-essential elements in gluten-free and gluten-containing products.

Boxplots use quartiles to visualise numerical data. A coloured box is set between the first and third quartile (Q1 and Q3) of the dataset. This area is also called *the interquartile range* (IQR), which means that 50% of the datapoints are located inside the box, as well as the median of the whole dataset. The median value is marked with a horizontal line inside the box. Lines that are drawn outside the box, also called *whiskers*, are set to correspond the extreme values of the dataset. They are set so that the upper whisker ends at Q3 + 1.5 x IQR. Similarly, the lower whisker ends at Q1–1.5 x IQR. Datapoints outside this range are considered possible outliers. They are marked with black dots.

As boxplots do not really give a good depiction of the distribution of the data points, all the datapoints were drawn as smaller black dots in the boxplot figure to show the number of points as well as the distribution. Also, basic statistical parameters are provided above the boxplot figures. These include the number of datapoints, the mean and median values, standard distribution, and minimum and maximum values.

6.3 Principal component analysis (PCA)

The results of this project included 42 different parameters, both nutrients and non-essential elements. To visualise the correlations between different nutritional facts, each of these parameters can be considered as one dimension in a coordinate system. With this thought, it is very difficult to visualise multiple dimensions, so a data reduction method was needed.

PCA is a multivariate statistical method for reducing the complexity of data. The idea is to create a set of new variables as linear combinations from the original parameters. These new variables are called *the principal components* (PCs). They are calculated so that the first PC is set in the same direction as the largest variation between the data points. This means that the PCA emphasises the parameters that contains the most variation inside them. Parameters that have lower variance give a lower contribution to the PCs. Like the first PC, the second is set in the same direction as the second-largest variation in the data, but so that it is also orthogonal to the first PC. The rest of the PCs are calculated similarly. They contain the largest variation in the data that is left, so that all the PCs are always orthogonal to each other.

By plotting the first two PCs in an *X-Y* coordinate system, the whole data can easily be studied in two-dimensional space. This means that the contribution of all the parameters involved is shown in a simple graphical form. In this way the parameters that cause the gluten-containing products and gluten-free products to separate in the PCA plot become visible. As the first two PCs contain most of the total variance of the data, the data loss by plotting these PCs is minimal. By using PCA, possible correlations between the different variables can also be easily identified.

6.3.1 Data standardisation

In the present study, the values are given in altering units of measure. Some of the parameters – for example, energy – have values in thousands while the different minerals have values below 1. To make all parameters comparable, the data values needed to be standardised before PCA. This was done by subtracting the mean of the parameter values from all its datapoints. These remainders were then divided by the standard deviation. As the analysis was done with R software (R Core Team, 2019), the standardisation is done automatically.

6.3.2 PCA with the R program

All the statistics and graphics were done with R and RStudio. The PCA calculations were done by using the *prcomp* function in the built-in *stats* package of R. All the graphical illustrations were made by using the *ggplot2* package from the core *tidyverse* (Wickham et al., 2019).

The key numerical concepts of PCA are the two matrixes: rotations of the variables and scores of the individual data points. Both can be calculated with the prcomp function. In this, the term *rotations* means a table containing PCs as columns and all the original variables as rows with a numerical value between -1 and 1, describing how much each original parameter contributes to a specific PC. A score table has all the individual results as rows and a coordinate point is calculated for each PC. The values of the coordinate points are centred so that when plotted to the *X-Y* coordinate system, they will spread on both sides of zero.

An *eigenvalue* is a term that describes the variation in each PC. More variation in the PC means more explanation of the total variance of the original data. As the data is standardised before the PCA, eigenvalues above 1 explain more of the total variance than one individual original variable could explain.

Typically, only the two first PCs are presented in a PCA plot. This means that some of the total variance is always lost. With eigenvalues we can calculate the percentage of the explained variance of these two first PCs. By adding together the eigenvalues of the first two PCs and dividing that with the number of original parameters, we get the percentage of the explained variance of the first two components. As the data is standardised before PCA, the variance of each variable is 1. That is why the sum of all eigenvalues is also the number of the original parameters.

The PCA plots presented in the next chapter ('Results and discussion') consists of four separate plots (Figures 5-8 and 10-12). A major plot shows the score data of the individual results of the first two PCs. The data points are coloured accordingly their gluten content. Rotation data is shown on the lower part of the image, in the middle. Arrows describe in which direction the original variables contribute to the PCs. The longer the arrow, the more significance it has. Also, the eigenvalues of all the PCs are shown in the lower-right corner. And on a plot on the left, the same values are presented as percentages. Above the plot on the left, the bars are calculated as the cumulative variance when adding together the eigenvalues of the PC, starting from the first PC.

6.3.3 Factor scores

In addition to the PCA figures, the numerical values of the PCA for individual products were also observed by evaluating the factor scores. These factor scores are the coordinates of the observations on the PC axes. Values are taken from the matrix called *x,* which is returned by the prcomp function in R.

To recognise the variables that have the most impact on each PC, the coordinates of the variables were evaluated. Coordinates were calculated by multiplying the standard deviation of the PCs with the loadings of the parameters. These values are the matrixes *stdev* and rotations, returned by using the prcomp function.

7. Results and Discussion

A set of new analytical results for gluten-free products were obtained in this study. The results will be added to the FCDBs of Finland, Norway and Sweden. The new analytical results for gluten-free products, as well as all the values of the gluten-containing products used in this study, are presented in Appendix 2 as fresh weights (FWs).

7.1 Wilcoxon's Mann-Whitney rank sum test

The confidence interval of the Mann-Whitney test was 95% with a threshold of significance of 0.05. Thus, all the parameters with *p*-values <0.05 are considered to differ significantly between gluten-free and gluten-containing products. The medians, range (min.–max.) and *p*-values of the studied nutrients and non-essential elements are presented in Table 8. For additional information regarding distribution, mean and standard deviations, see the boxplots in Figures 1–4. If any of the nutritional values of a product were missing, it could not, of course, be used in the calculations. If data on the limit of detection (LOD) or limit of quantification (LOQ) values were available, half-values (LOD/2 or LOQ/2) were used in the statistical calculations.

Table 8. Nutrients and non-essential elements in gluten-free and gluten-containing products presented in dry weights.

Note: The values are calculated from dry matter corrected results.

		Gluten containing	Gluten free	Gluten containing	Gluten free	Gluten containing	Gluten free		GF/GC*
					Nutrients				
	Unit	*n*	*n*	*Median*	*Median*	*Range*	*Range*	*p-value*	
Energy	kJ	134	36	1677	1685	1400–2711	1433–2125	0.750	-
Fat	g/100g	134	36	3.0	3.8	0.06–31	<LOQ–29	0.420	-
Protein	g/100g	134	36	13	7.2	0.21–20	1.4–20	0.000	↓
Salt	g/100g	134	36	0.8	0.9	<LOQ–2.2	<LOQ–2.6	0.402	-
Starch	g/100g	134	36	66	73	28–99	31–96	0.006	↑
Total DF	g/100g	134	34	8.4	8.1	<LOQ–25	1.3–27	0.802	-
Total sugars	g/100g	134	36	2.3	3.6	<LOQ–47	0.06–26	0.690	-
Ca	mg/100g	64	36	33	32	<LOQ–170	2.5–190	0.980	-
Cu	mg/100g	63	36	0.3	0.2	22–670	13–790	0.001	↓
Fe	mg/100g	64	36	2.6	2.4	0.22–9.1	0.16–13	0.605	-
K	mg/100g	64	36	350	200	12–740	51–713	0.000	↓
Mg	mg/100g	64	36	68	55	1.1–200	9.4–320	0.156	-
P	mg/100g	64	36	260	150	7.9–580	44–700	0.005	↓
Zn	mg/100g	64	36	2.0	1.2	0.13–5.6	0.25–5.8	0.000	↓
Co	µg/100g	32	36	2.2	2.8	<LOQ–8.7	0.33–11	0.454	-
Cr**	µg/100g	39	36	2.2	9.4	<LOQ–24	<LOD–72	0.000	↑
Mn	µg/100g	40	36	1500	830	4.5–5000	38–11000	0.013	↓
Mo	µg/100g	38	36	23	25	<LOQ–81	<LOD–130	0.427	-
					Non-essential elements				
	Unit	*n*	*n*	*Median*	*Median*	*Range*	*Range*	*p-value*	
Al	µg/100g	24	36	800	620	<LOQ–2100	<LOD–5100	0.994	-
Cd	µg/100g	35	36	3.0	1.8	0.63–47	<LOD–18	0.122	-
Ni	µg/100g	22	36	12	40	<LOQ–57	2.7–380	0.001	↑
Pb	µg/100g	19	36	<LOQ	0.86	<LOQ–3.0	<LOD-8.7	0.004	↑

* Content in a gluten-free product compared with content in a gluten-containing product.
↑ Indicates a higher level in a gluten-free product.
↓ Indicates a lower level in a gluten-free product
– Indicates no significant difference
** Chromium is an essential element but can also be toxic, depending on the chemical form (CrIII essential vs CrVI toxic)

The contents of protein, Cu, K, P, Zn and Mn were significantly lower in the gluten-free products compared with the gluten-containing foods. The contents of Cr, Ni, Pb and starch were significantly higher in gluten-free products.

Since the tests were performed on the median values of all the included products, one can draw the conclusion that, in general, it seems that the intake of only gluten-free products, within the tested categories, would result in a higher intake of the non-essential elements Ni and Pb. Additionally, it would also lead to a lower intake of the essential elements Cu, K, Mn, P and Zn. The total levels of Cr are higher in gluten-free products but no analysis of the different forms of Cr was performed.

However, care must always be taken when comparing levels in generic/composite samples with individual products. According to the most recent market-basket survey in Sweden (SFA, 2017), the mean (range) of the non-essential elements in five composite samples of cereals (bread, flour, muesli, pasta, rice) were (in FW): 306 µg Al/100g (87–1075 mg/100g), 2.5 µg Cd/100g (2.2–3.3 mg/100g), 19 µg Ni/100g (12–27 mg/100g) and 0.5 µg Pb/100g (0.3–0.7 mg/100g). Compared with this study, the levels of Al are lower than both the gluten-containing and gluten-free products (689 and 1036 µg/100g). The mean levels of Cd are similar in the market-basket and gluten-free products (2.5 µg Cd/100g FW) while the mean levels (in FW) for Ni and Pb were higher in the gluten-free products (65 µg/100g [2.4–354 mg/100g] and 1.3 µg/100g [0.03–5.9 mg/100g], respectively). Note that the wide ranges of Ni and Pb in gluten-free products (individual samples) are not directly comparable with the market-basket ranges for the five composite samples, but the wide distribution in gluten-free products is also not seen in the gluten-containing products in this study, being 1.8–50 mg/100g and <LOQ–2.8 mg/100g for Ni and Pb, respectively.

For the essential elements, the means (range) in the five market-basket composite samples of cereals (bread, flour, muesli, pasta, rice) were (in FW) as follows: 1.6 µg Cr/100g, 202 µg Cu/100g, 1055 µg Mn/100g, 1.6 mg Fe/100g, 1.3 mg Zn/100g, 253 mg K/100g and 164 mg P/100g. The mean levels of Cr in the market basket are lower than the gluten-containing products in this study (3.3 µg/100g FW) and also much lower than in the gluten-free products (12.0 µg Cr/100g FW). The mean values for Cu, Mn and Fe were higher in this study than in the market basket for both gluten-free and gluten-containing products (213 and 273 µg Cu/100g, respectively; 1102 and 1392 µg Mn/100g, respectively; and 2.6 and 2.4 mg Fe/100g FW, respectively). For Zn and P, the mean values in the market-basket cereal group are more similar to the results from the gluten-free products in this study (being 1.2 mg Zn/100g and 171 mg P/100g FW) when compared with the gluten-containing product mean values (1.8 and 222 mg/100g FW), which are somewhat higher. On the contrary, the mean level of K in the market basket (253 mg/100g FW) is more similar to the mean of gluten-containing products (279 mg/100g FW) than to the gluten-free products (198 mg/100g FW).

This simple comparison with mean values from the market-basket study roughly confirm that the levels of Ni and Pb, as well as Cr, seem to be higher in gluten-free products and that levels of K are lower. Considering Cu, Fe, Mn, P and Zn, the results are not as straightforward to interpret and care must always be taken when comparing levels from different studies.

7.2 Boxplots

Boxplots were made to display variation in the products. All the products, except sugar beet (PCA ID 9), both gluten-free and gluten-containing products, were plotted in the same figure to visualise the differences between the products with and without gluten. Boxplots for the major nutrients in all the samples are presented in Figure 1 and for the chemical elements in Figures 2–4.

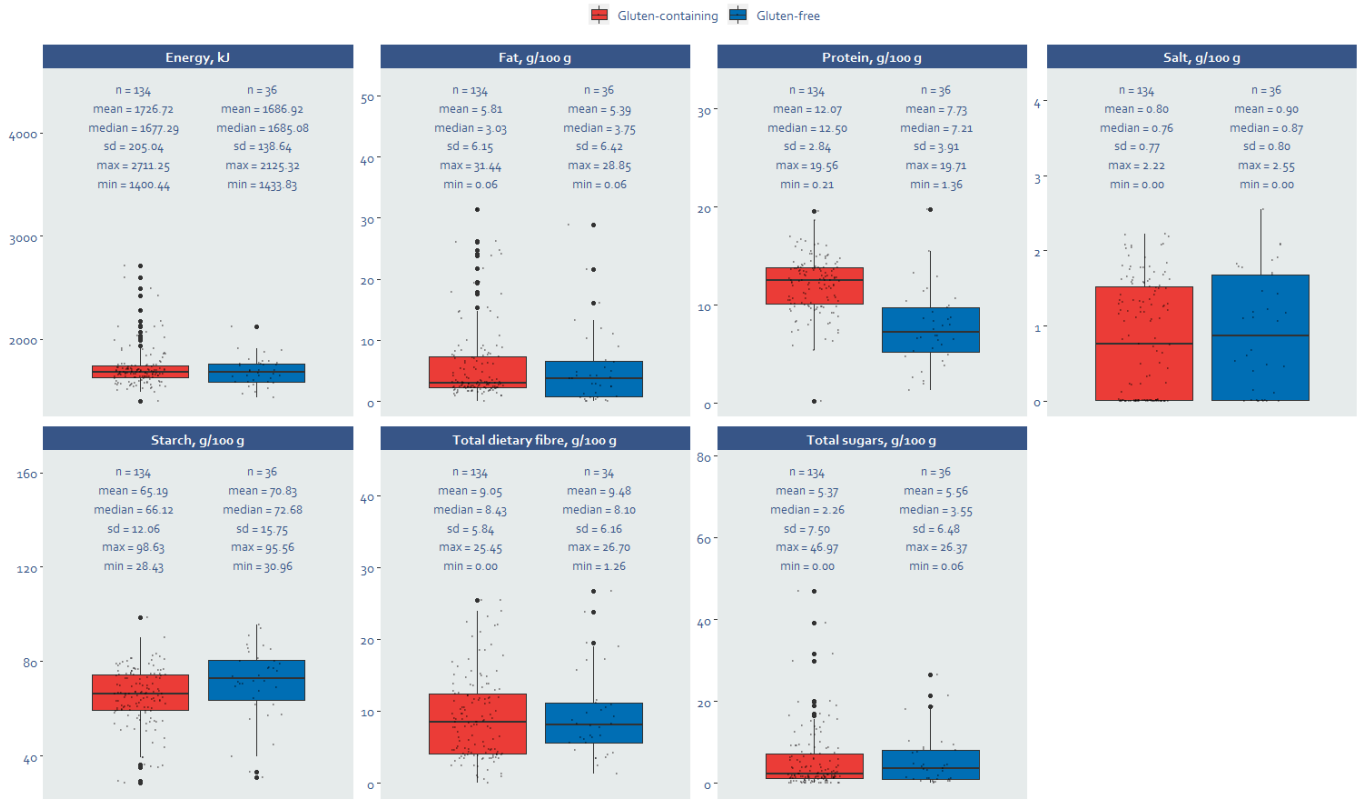

Figure 1. Boxplots of the major nutrients (g/100g) in all gluten-containing and gluten-free products. The results are presented in dry weight.

As was also shown in Table 8, the boxplot in Figure 1 shows that the amount of protein was significantly lower in the gluten-free products. The mean value of protein in gluten-free products was 7.7 g/100g (calculated as dry weight [DW]), whereas the gluten-containing products contained 12.1 g/100g DW protein on average. Of the gluten-free products, the second highest protein content was found in a sample of coarse buckwheat flour (PCA ID 6) (19.6 g/100g DW), which had the highest content as FW, but interestingly, the content of the second buckwheat flour sample (PCA ID 4) was among the lowest of all the analysed results, with only 2.0 g/100g DW. A third sample of buckwheat flour (PCA ID 11), with a slightly lower protein content than the first sample (15.5 g/100g DW), was also included. In summary, at least in some cases, the results of individual products can vary considerably. This points out that caution is needed when interpreting the results.

A range of generic wheat flours and products from different brands showed protein concentrations above the mean value of all gluten-containing containing products. The gluten-containing group included 21 different wheat flours with a protein content range of 10–20 g/100g protein (mean 14 g/100g DW protein). Because the proportion of wheat flours in the gluten-containing products group was so large, it affected the group average. Excluding wheat flour, the average protein content of gluten-containing products was 11.7 g/100g, expressed as DW (median 12.2 g/100g DW). However, the mean and median change very little without wheat flour, so they alone are not enough to explain the differences between the protein content of gluten-free and gluten-containing products. In the gluten-containing group, tapioca flour (naturally gluten free, not labelled as *gluten free,* in this data) showed a low concentration of protein (0.2 g/100g DW). Because tapioca flour is inherently gluten free, its inclusion in the group of gluten-free products would further lower the average protein content of the group.

Starch content was significantly higher in the analysed gluten-free products (*p*-value = 0.006; see Table 8), although the difference was not as great as in protein contents (see Figure 1). An especially high starch concentration was found in rice flour and rice flakes (94.0 and 95.6 g/100g DW, respectively; PCA ID 7 and 16, respectively). Furthermore, tapioca flour contained a high concentration of starch (98.6 g/100g DW) in the gluten-containing group. Again, moving the tapioca from one group to another would further reinforce the difference. Half of the wheat flours in the study contained less starch than the analysed gluten-free products on average. Furthermore, the starch content of rye flour (39–77 g/100g DW) was, in most cases, below the starch average of gluten-free products (70.8 g/100g DW). As a result, the starch content of several gluten-containing flour mixtures that include rye flour was also lower.

Energy values did not differ significantly between the gluten-free and gluten-containing products. However, the distribution is broader in the group of gluten-containing products. All but one gluten-free product contained less than 2000 kJ/100g DW of energy, while there were several gluten-containing products, such as cookies and salty crackers, with an energy content of more than 2000 kJ/100g DW.

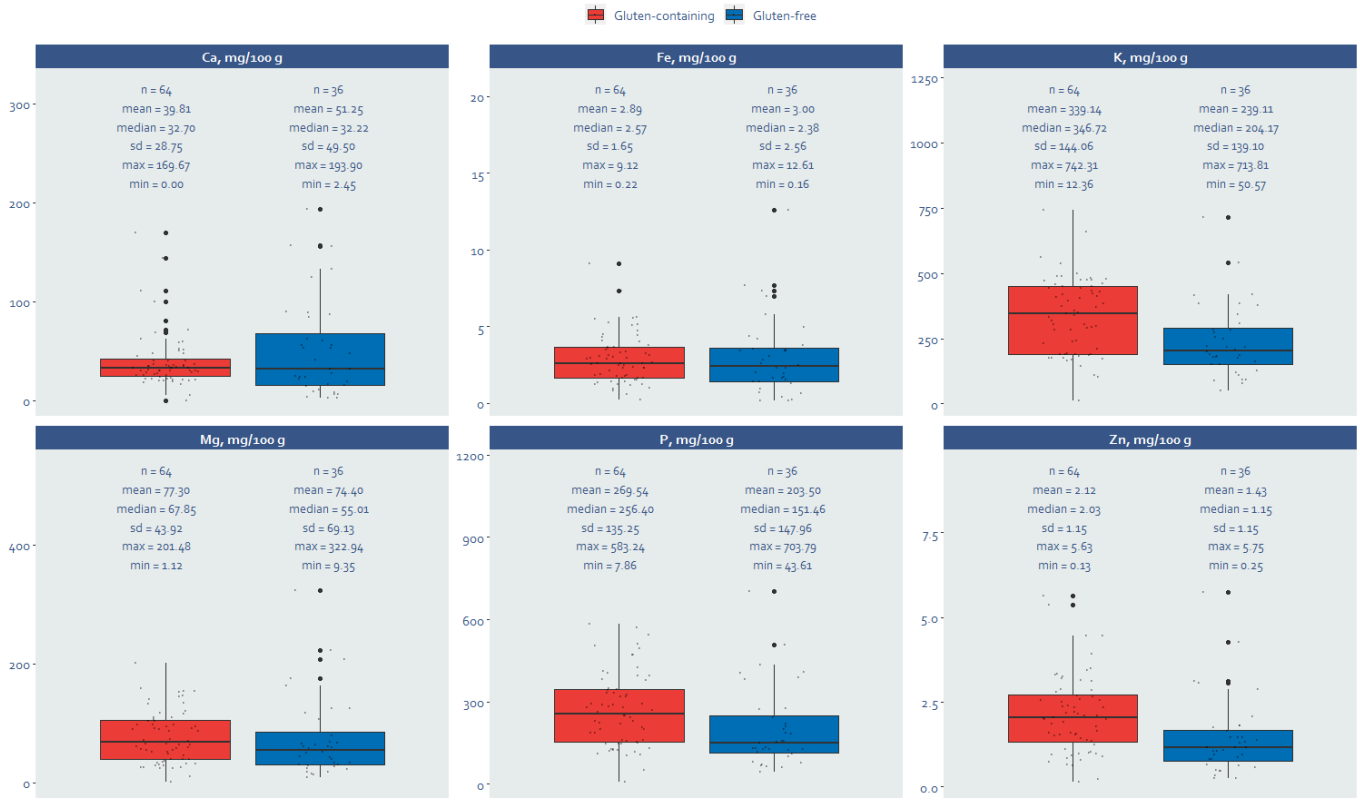

Figure 2. Boxplots of the essential elements (mg/100g) in gluten-containing products (generic data) and gluten-free products (specific products). The results are presented in DW.

The contents of potassium, phosphorus and zinc were significantly higher in gluten-containing products. However, looking at the ranges, there were gluten-free products that contained high amounts of K, P and Zn. The highest concentrations of K, P and Zn were found in coarse buckwheat flour (PCA ID 6), muesli with raisins and figs (PCA ID 90), granola with blueberries (PCA ID 91) and teff flour (PCA ID 8). In all four products, the concentrations of all of these three elements – K, P and Zn – were among the highest.

In Nordic diets, high levels of Ca are generally found in dairy products. In this study, teff flour (PCA ID 8) had the highest Ca concentration among the gluten-free products. If teff generally contains high levels of Ca, it might be good source of Ca for people with a milk protein allergy. Overall Ca, Fe and Mg were found at similar levels in products that are free from gluten and those containing gluten. Iron and magnesium levels seemed equally distributed in the gluten-free and gluten-containing products.

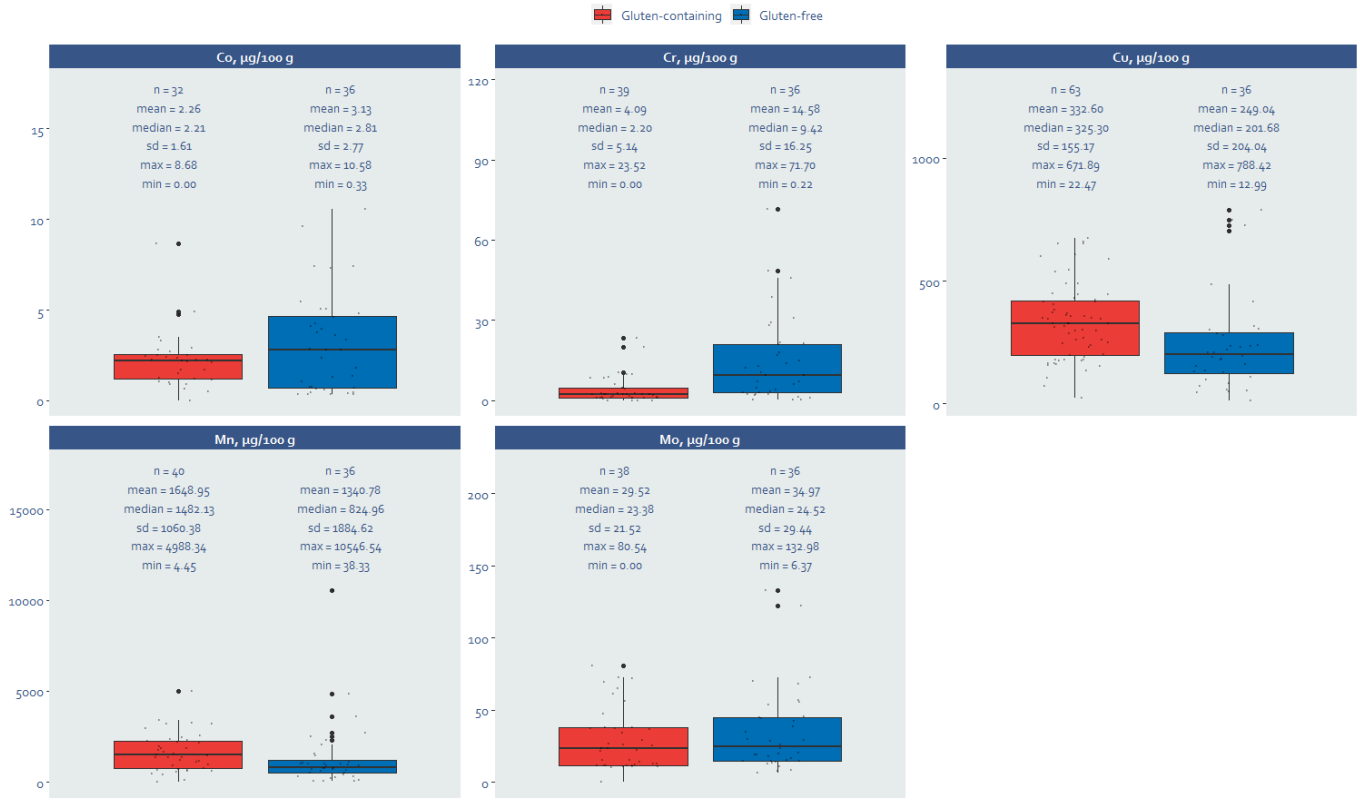

Figure 3. Boxplots of the essential elements (mg/100g) in gluten-containing products (generic data) and gluten-free products (specific products). The results are presented in DW.

The content of manganese and copper was significantly lower in gluten-free products, whereas the contents of chromium were significantly higher, even when the sample with the highest concentration was excluded (i.e. PCA ID 9, sugar beet, with 296 mg Cr/100g FW). Of the gluten-free samples, 14% (5 of 36 samples) contained Cr levels above the highest level in gluten-containing products (21 mg/100g FW, found in wholegrain spelt flour [PCA ID 51]). For levels of Mn, the distribution is large in both gluten-free and gluten-containing products. The highest level found was in the gluten-free teff flour (PCA ID 8) with 10 550 µg/100g DW (9745/100g FW). Also, the following gluten-free products contained high levels of copper (650–708 µg/100g FW): wholegrain buckwheat flour (PCA ID 6), muesli with raisins and figs (PCA ID 90), granola with blueberries (PCA ID 91) and teff flour (PCA ID 8); these are the same four products that contained the highest amount of K, P and Zn. Sugar beet (PCA ID 9; not present in the boxplot, see Figure 3) contained the highest amount of Co (16 µg/100g FW), followed by wholegrain buckwheat flour (PCA ID 6; 9.5 µg/100g FW). For Mo, only two gluten-free products – granola with blueberries (PCA ID 91) and wholegrain oat flour (PCA ID 5) – had higher levels of Mo (125 and 111 µg/100g FW, respectively) than the products with gluten.

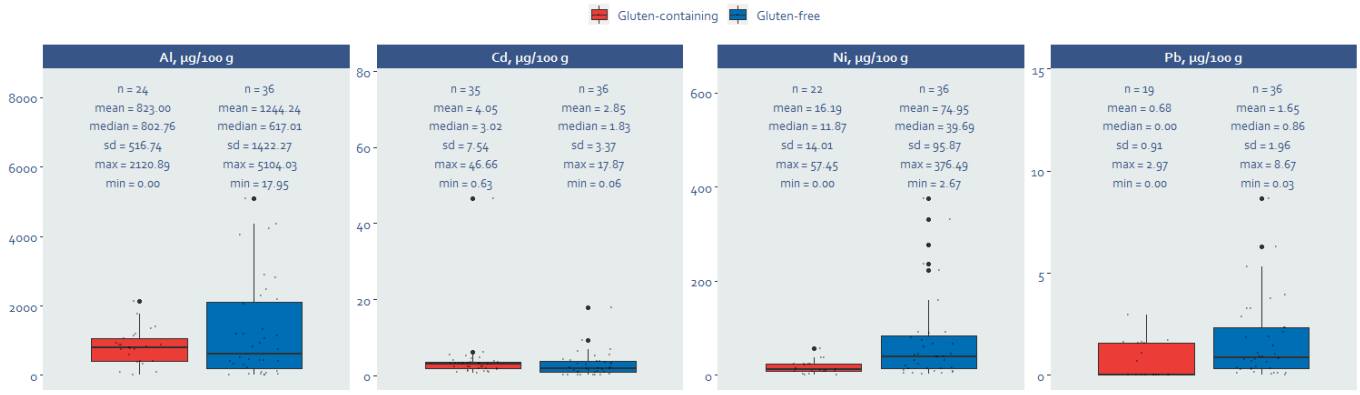

Figure 4. Boxplots of non-essential elements (µg/100g) in gluten-containing products (generic data) and gluten-free products (specific products). The results are presented in DW.

The contents of nickel and lead were significantly higher in the gluten-free products, even when sugar beet (PCA ID 9), which contained the highest levels of Pb (93 µg/100g FW), was excluded (see Figure 4). The second highest Pb concentration was found in the gluten-free flour mix (PCA ID 12), which had 5.9 mg Pb/100g FW**.** Regarding Ni, the three products with the highest values were granola with blueberries (PCA ID 91), teff flour (PCA ID 8) and muesli with raisins and figs (PCA ID 90), which had the levels of 354, 306 and 253 µg Ni/100g FW, respectively. Pb levels in the coarse gluten-free flour mix (PCA ID 12) and oat bread mix (PCA ID 13) were the highest after sugar beet (PCA ID 9), with 5.9 and 5.0 µg Pb/100g FW for PCA ID 12 and PCA 13, respectively. Crispbread with sesame seeds and sea salt (PCA ID 112) contained a considerable amount of Al (4813 µg Al/100g FW), and teff flour (PCA ID 8) had the second highest amount of Al after PCA ID 112: 4019 µg Al/100g FW. In the gluten-containing products, the highest Al value (2000 µg/100g FW) was found in crispbread with sesame seeds and wheat bran (PCA ID 157). This product also contained the highest level of Cd: 44 µg/100g FW.

Among the non-essential elements, only inorganic arsenic (iAs), Cd and Pb have the EU's maximum levels in the food categories analysed (see Table 9). Since most of the products contain more than one ingredient, the maximum levels cannot be applied directly to the product in itself but have to be recalculated according to the composition of each ingredient. However, the maximum level for cereal-based infant food (4 and 5 µg/100g for Cd and Pb, respectively) also considers mixtures of ingredients. None of the gluten-free products in this study are labelled as *baby food* nor are any intended for young children, but nevertheless, they could be consumed as such. Of the gluten-free cereal-based products tested, 63% (23/36 products) exceeded the maximum level for Pb in cereal-based food intended for infants and young children. For Cd, the percentage was 38% of the gluten-free products (14/36 products) and 3% of the gluten-containing products (1/35 products). Very few values for Pb in gluten-containing products are presented in this report, but comparing Pb levels in data collected for cereals, nuts and seeds over 40 years (Jorhem et al., 2015) has revealed that only three products analysed recently (i.e. after the year 2000) exceeded 5 µg/100g (two pine seed samples were 5.4 and 10 µg/100g and wheat grain was 9.1 µg/100g). This means that people substituting common cereal

products with the same kind of gluten-free products as those analysed in this work will have a higher intake of Pb in general.

The level of inorganic arsenic in rice intended for infants and young children should not exceed 10 µg/100g. In this work, only total arsenic was analysed and 5 of 36 (13%) products exceeded the maximum level for inorganic arsenic. This is well in line with the work of Kollander et al. (2015), showing that the majority of the rice and rice products (excluding rice cakes, drinks and porridge) had levels below 10 µg inorganic arsenic per 100 g FW, and 14% exceeded the maximum level for inorganic arsenic in rice intended for infants and young children.

As can be seen in Table 9, there are so far no EU maximum levels regarding As, Cd and Pb for nuts and seeds, and no maximum levels at all for Ni. However, EFSA concludes – in their 2016 evaluation regarding Ni – that a high intake may be of concern (EFSA, 2015). Also, the maximum levels of chromium are missing, but in their scientific opinion, EFSA concludes there is a need for data on chromium species (CrIII and CrVI) in food (EFSA, 2014). The maximum levels are routinely updated by the European Commission based on the evaluations of EFSA. To date, the most recent evaluations from EFSA regarding Pb, Cd, Hg and iAs were given in 2010, 2012, 2014 and 2014 respectively.

Table 9. The ranges of the EU maximum levels (in µg/100g), expressed as FWs in order to be comparable with the levels of the products in Appendix 2. In the legislation, they are normally expressed in mg/kg (EC 1881/2006).

Food category	Inorganic arsenic µg/100g FW	Cadmium µg/100g FW	Lead µg/100g FW
Cereals	-	10–20	20
Rice	10–30	20	20
Infant food	-	0.5–4	1–5
Vegetables	-	0.5–20	5–30
Fruit and berries	-	-	3–20
Nuts and seeds	-	-	-

7.3 Principal component analysis (PCA)

The results for individual sugars and DF fractions were not utilised in the PCA. Comparisons with the gluten-containing foods were not possible for the nutrients mentioned above because of the lack of information on the product packages and in the FCDBs. However, the contents of total sugars and total DF were compared using PCA. Furthermore, because of the missing information on the chemical elements, I, Se, As, Ag and Hg were also excluded from the PCA. In addition to nutrients, three products were discarded as outliers from the PCA (PCA ID 9, Fibrex sockerbetaflinga; PCA ID 43, 2 dl semi-coarse flour + 1 ts baking powder; PCA ID 72, bran flakes).

PCA analysis was performed for all the products at first (all the gluten-free and

gluten-containing products; see Figure 5). Category 1 ('Cereals and flakes') differed nicely from the other products, mainly based on the category's products' starch, protein and DF contents. Category 2 ('Cereal flakes, processed') showed a larger distribution, and in Category 3 ('Muesli and granola'), the grouping of products could be observed due to, for example, high fat and sugar values. Products in Category 4 ('Bread and wraps') separated nicely from Category 1 along the *y*-axis because of the higher fat, salt, sugar and energy contents.

Different product groups were separated to some extent in the PCA on the basis of the main nutrients, which supports the decision to look at the product groups separately as well. However, only Categories 1 and 4 contained enough products for PCA in all product groups (gluten-free products, branded gluten-containing products and generic gluten-containing products) and a sufficient number of results for comparing major nutrients and chemical elements. Other, smaller groups were examined descriptively.

The results from the PCA are presented in Figures 5 to 12, together with the information about the variables. Two-dimensional plots are shown wherein eigenvalues PC1 and PC2 are the visible dimensions. The variables affecting PC1 and PC2 are shown as two-dimensional coordinates. Thus, these variables explain the most of variance detected.

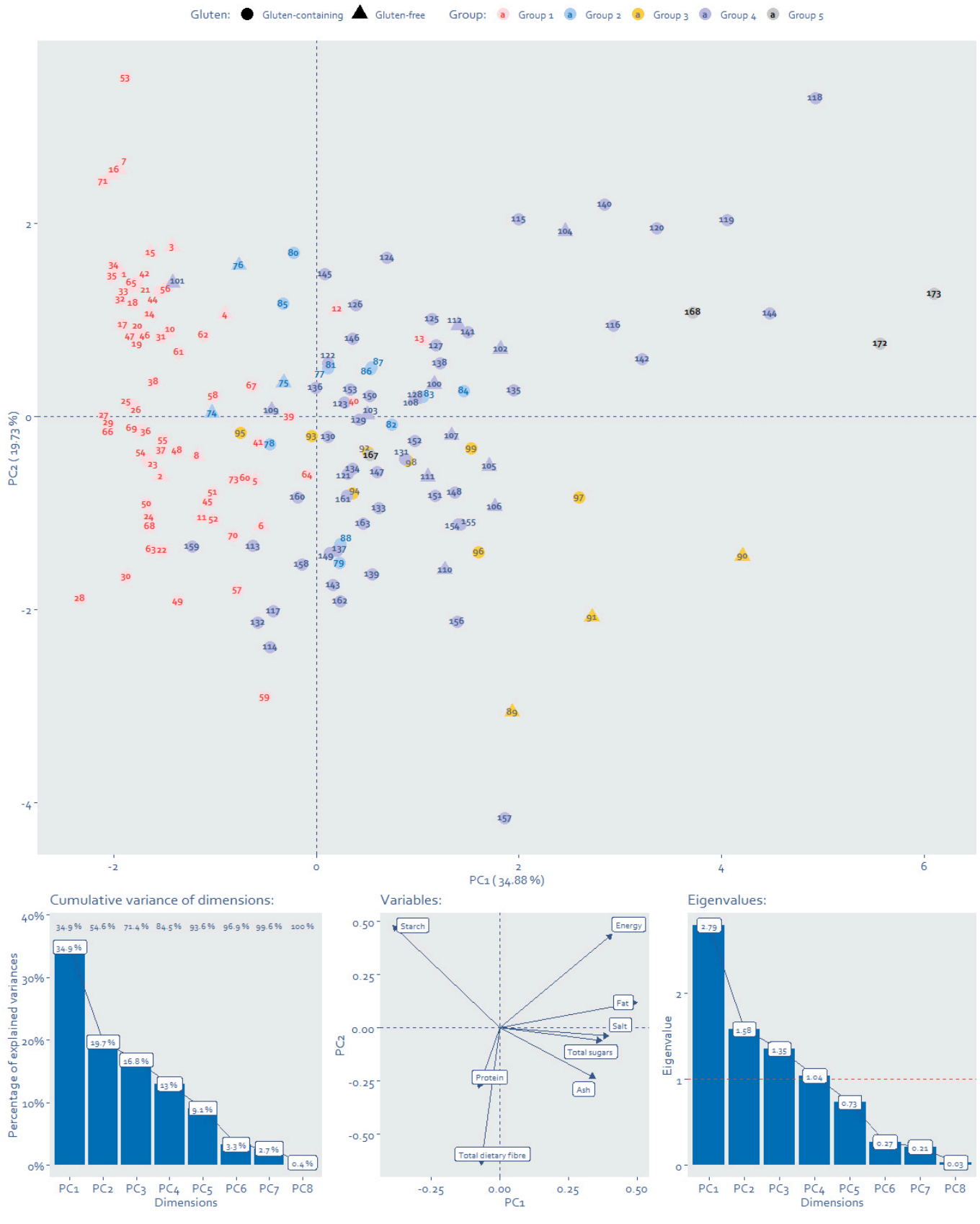

Figure 5. PCA of the major nutrients in all the products, in FWs.

7.3.1 Category 1: Flours and flakes

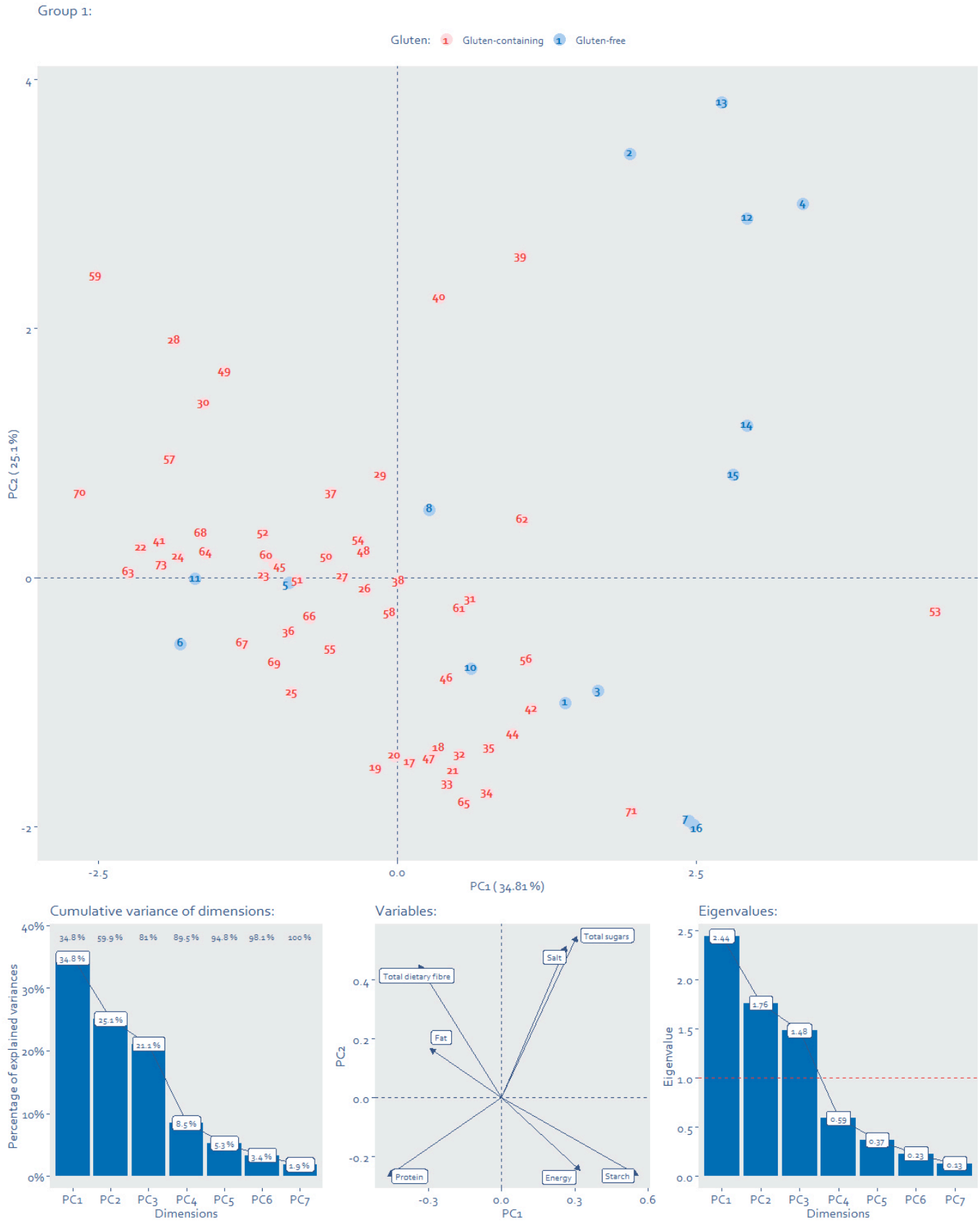

Figure 6. The major nutrients in flour and flake products (Category 1). PCA was performed on results in DW.

There is a group of four gluten-free products that contain more total sugars and salt (upper right in Figure 6) than the other products. Three of the products are baking mixes (PCA IDs 2, 12 and 13) while PCA ID 4 is buckwheat flour. The baking mixes contain dextrose in variating amounts, which obviously contributes to high total sugar. In addition, these products contain added salt. Except for these four products, the gluten-free products appear more or less spread out in the same way in the PCA (Figure 6) as the gluten-containing products, although we find more gluten-containing products further away from the centre of the PCA chart. For instance, products with high energy and protein are mostly gluten containing (shown in the lower middle section of the large PCA chart in Figure 6), which is also seen regarding the total fibre content (shown in the upper left section). Products with the highest content of DF, shown in the upper left-side section in Figure 6, are all gluten containing.

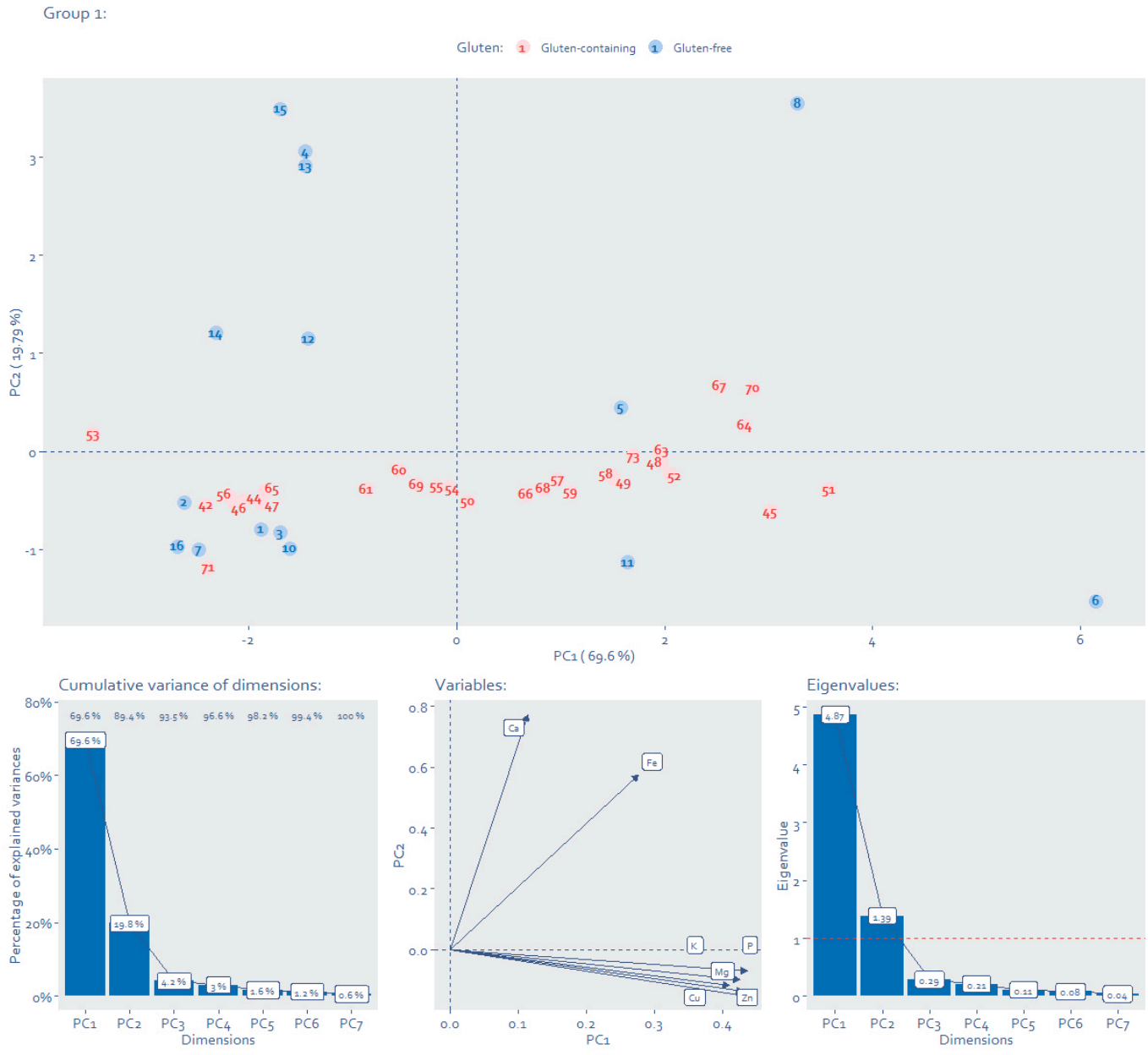

Figure 7. The minerals / essential elements in Category 1 ('Cereals and flakes'). PCA was performed on results in DW.

In Figure 7, the PCA shows the essential elements in cereals and flakes. PCA ID 15 is a flour mix for baking bread with wheat starch and skimmed milk as the main ingredients. Teff flour (PCA ID 8; in the upper-right section of the large chart in Figure 7) clearly has another composition of minerals, especially iron, compared to the other products. Also, PCA ID 6, coarse buckwheat flour, contains higher amounts of several minerals compared with the other products in this group.

In the upper-right quarter in Figure 7, there are a group of oat products, both gluten-containing products (PCA ID 64, 67 and 70; not labelled as *gluten free*) and a gluten-free product (PCA ID 5). Oat per se is a wholegrain product if nothing else is stated. In the same vicinity of Figure 7 (at a similar distance to the *y*-axis) there are wholegrain wheat and wholegrain spelt flour (PCA IDs 45 and 51, respectively). In

fact, all gluten-containing products (the red circles) on the right side in the PCA chart are wholegrain products, which is expected since wholegrains are known to contain high levels of magnesium, potassium, zinc and phosphorous (SFA, 2020). Also, the gluten-free product buckwheat flour (PCA ID 11), is placed on this side of the PCA.

In the centre of Figure 7, there are a couple of flours, either mixed or pure wheat, durum and rye flours. Among the products tested, 73% (11/15) of the gluten-free products are on the left side, which means they have a lesser content of essential elements.

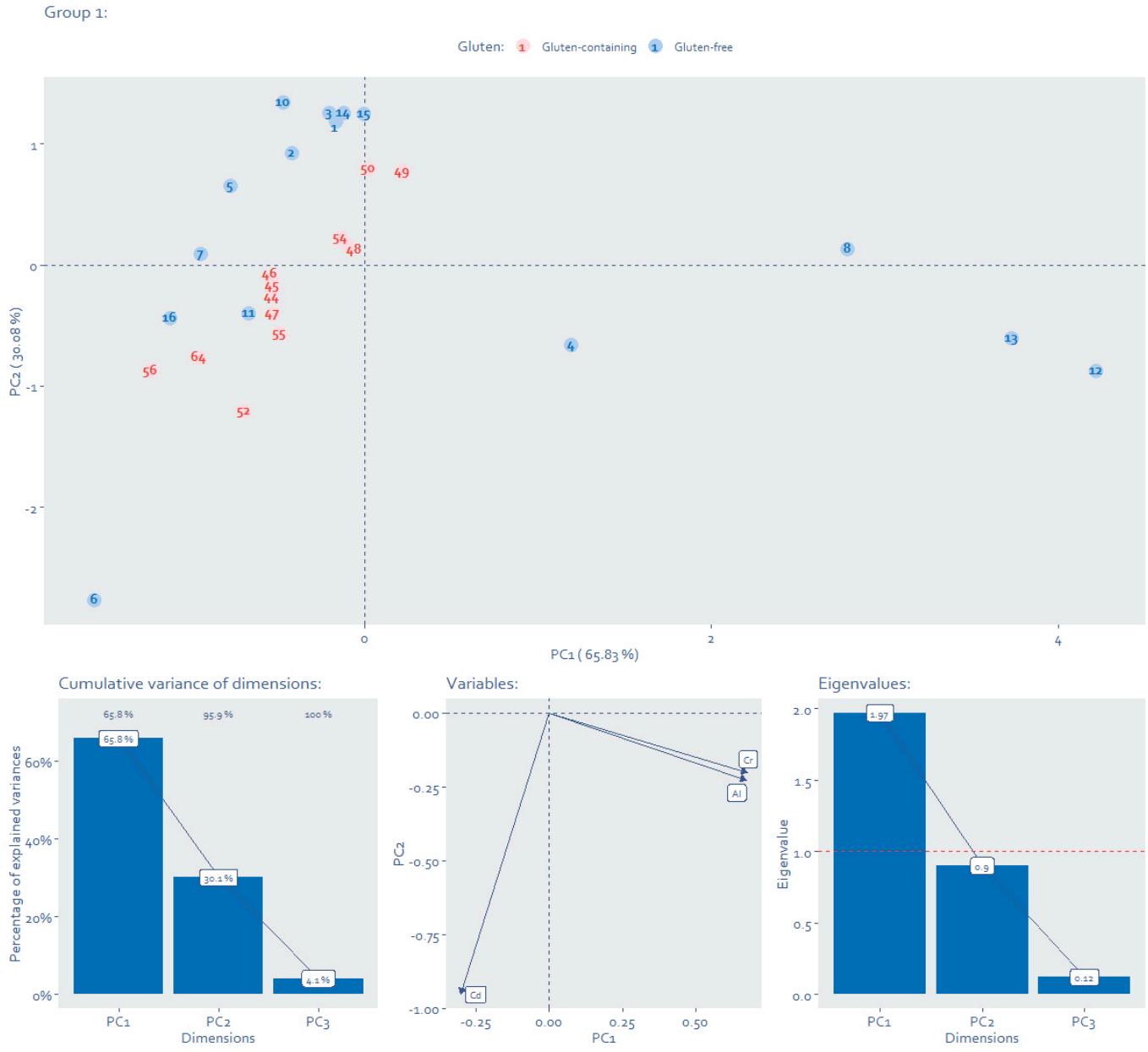

Figure 8. Cadmium, aluminium and chromium in flours and flakes (Category 1). PCA was performed on results in DW.

The products on the right of the large PCA chart in Figure 8 contain buckwheat (PCA IDs 4, 12 and 13), sesame seeds (PCA IDs 12 and 13) and teff (PCA ID 8). On the contrary to the buckwheat flour PCA ID 4, the other two buckwheat flours (PCA IDs 6 and 11) are placed to the left in the PCA chart, indicating a lesser amount of Al and Cr. The coarse buckwheat flour (PCA ID 6) contained 8.3 µg Cd/100g and is placed in the lower left corner of the PCA chart shown in Figure 8. Products with higher Cd values, not included in Figure 8, are sugar beet flakes (PCA ID 9, 18 µg/100g FW) and granola with blueberries (PCA ID 91, 17 µg/100g FW). There was no significant difference between gluten-free and gluten-containing products regarding the levels of cadmium.

In the work of Jorhem et al. (2015), the reported levels of Cr and Cd in buckwheat were a bit higher than those of rye and wheat. However, the most recently analysed samples of buckwheat, reported in the work of Jorhem et al. (2015), were from 2006, indicating that new data are needed in general. According to the same report, sesame seeds can also have higher levels of Cr, which might explain the higher levels seen in the coarse flour mix (PCA ID 12) and in the oat bread mix (PCA ID 13). No data have been found regarding aluminium or teff.

7.3.1.1. PCA and factor score analysis of Category 1 ('Flours and flakes')

Nutrient co-occurrence patterns in foods are useful for understanding the association of the nutrients in basic foods or composite foods with different ingredients in the recipes. In this study, it was also possible to take the gluten content of the food product into account as each product was described as either a gluten-free or gluten-containing product.

A detailed description of the analysis process is described in Section 6.3. Based on the preparatory analysis (the eigenvalues of the PCs were about 1 or >1; see Figure 5), a four PC solution was picked for further analysis. The labelling of PC dimensions was based on factor scores (i.e. foods with high scores are used as important information, characterising the dimensions). Also, the nutritional composition, as well as the gluten content, was taken into account in the naming of the dimensions. Nutrients with loadings >0.4 or <-0.4 are presented.

The larger the factor loading of a given nutrient, the greater the correlation of that nutrient to the PC. A negative factor loading of a nutrient indicates that the nutrient is inversely associated with the pattern. The correlation matrix plot for the loadings of Category 1 are presented in Figure 9.

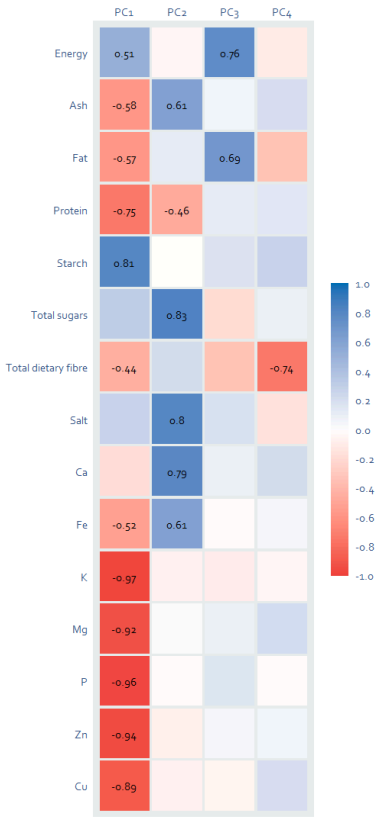

Figure 9. A generated PCA correlation matrix plot for the loadings in Category 1. Positive correlations are indicated in blue and negative in red. Loadings > 0.4 and < -0.4 are taken into account in the interpretations.

The four PC solution for 'Flours and flakes', the labelling of the dimensions, the nutritional interpretation and information, and whether or not typical products contain gluten and nutrients that are associated with the identified patterns are presented in Table 10. The variance explained by these four PCs was 83%. Examples of the food items characterising the PC (factor score: >1.0) are presented in the Appendix, Table 4.1.

The first pattern (PC1) of Category 1, which alone explains 48% of the total variance, was mainly characterised by rice, tapioca, corn, buckwheat flour-based products, being naturally gluten free, as well as by the gluten-free oat bread mix. However, some wheat-containing food products also got factor scores >1. The nutrients associated with this PC were starch and energy. At the same time, PC1 was characterised as being low in mineral, protein, fat and fibre, which can be interpreted to indicate that the typical foods of this dimension (with factor scores >1) only contain a small amount of these nutrients. Out of the typical products of this PC, 68% were identified to be gluten free.

Table 10. The four-dimensional solution for the nutrient content of 100 g food portions (the nutrient value solution): the factor loadings of the nutrients.

Dimension	PC1	PC2	PC3	PC4
Name	Starch energy factor (the rice–tapioca–corn–wheat factor)	Gluten-free flour mixes (cont. milk powder, fortified)	Oat and oil factor (oil-containing flour mixes)	Low-fibre gluten-free flours and flour mixes
Nutritional interpretation	High in starch and energy; low in minerals, protein, fat and fibre	High in sugar, salt, calcium and iron; low in protein	High in energy and fat	Low in fibre
Gluten free / gluten containing	Mainly gluten-free products	Gluten-free products	Both gluten-free and gluten-containing products	Gluten-free products
Variance explained (%) Total 83.3%	48	19.9	9	6.5
Loadings	Starch	Total sugars	Energy	None
>0.4	Energy	Salt	Fat	
		Ca		
		Fe		
		Ash		
Loadings	Potassium	Protein	none	Total DF
<-0.4	Phosphorus			
	Zinc			
	Magnesium			
	Copper			
	Protein			
	Iron			
	Ash			
	Fat			
	Total DF			

Two of the four dimensions (PC2 and PC4) were typical for gluten-free flour mixes: PC2 correlating with high sugar, salt, calcium and iron content and low protein content; PC4 only correlated negatively with fibre. All the foods with factor scores >1 were gluten-free products. One feature which seems to separate PC2 from PC4 was the fact that the typical products of PC2 were more often commercial gluten-free flour mixes that contained milk powder or were fortified with vitamins and some minerals. Most of the typical products of PC4 were naturally gluten-free flours, the Finax flour mix (PCA ID 15) and teff flour (PCA ID 8) being exceptions and getting a factor score >1 for both PCs. Together, these two PCs explained about 26% of the total variance in the data.

PC3 was characterised as correlating with high-energy and high-fat products. The

variance explained by this PC was 9%. All the typical foods of this dimension were either oat products or contained oat (and oil) as an ingredient in a mixture. The typical products were more often gluten-containing products (57%) than gluten-free products.

The analysis showed that certain nutrients gather into patterns among the flours and flour mixes in a pool of the Group 1 foods. This analysis confirmed that high starch and energy content and low total DF content are more common features to the gluten-free flour and cereal products compared with the gluten-containing flour and cereal products. The pattern solutions can be explained, at least partly, by the characteristics of the ingredients as such, being part of a flour-mix recipe or by fortification of the product. This seemed to be the case with some gluten-free flour mixes, which typically have some nutrients in high concentrations (e.g. calcium, iron and protein) due to fortification or due to having milk-based ingredients in their composition.

7.3.2 Category 4: Breads and wraps

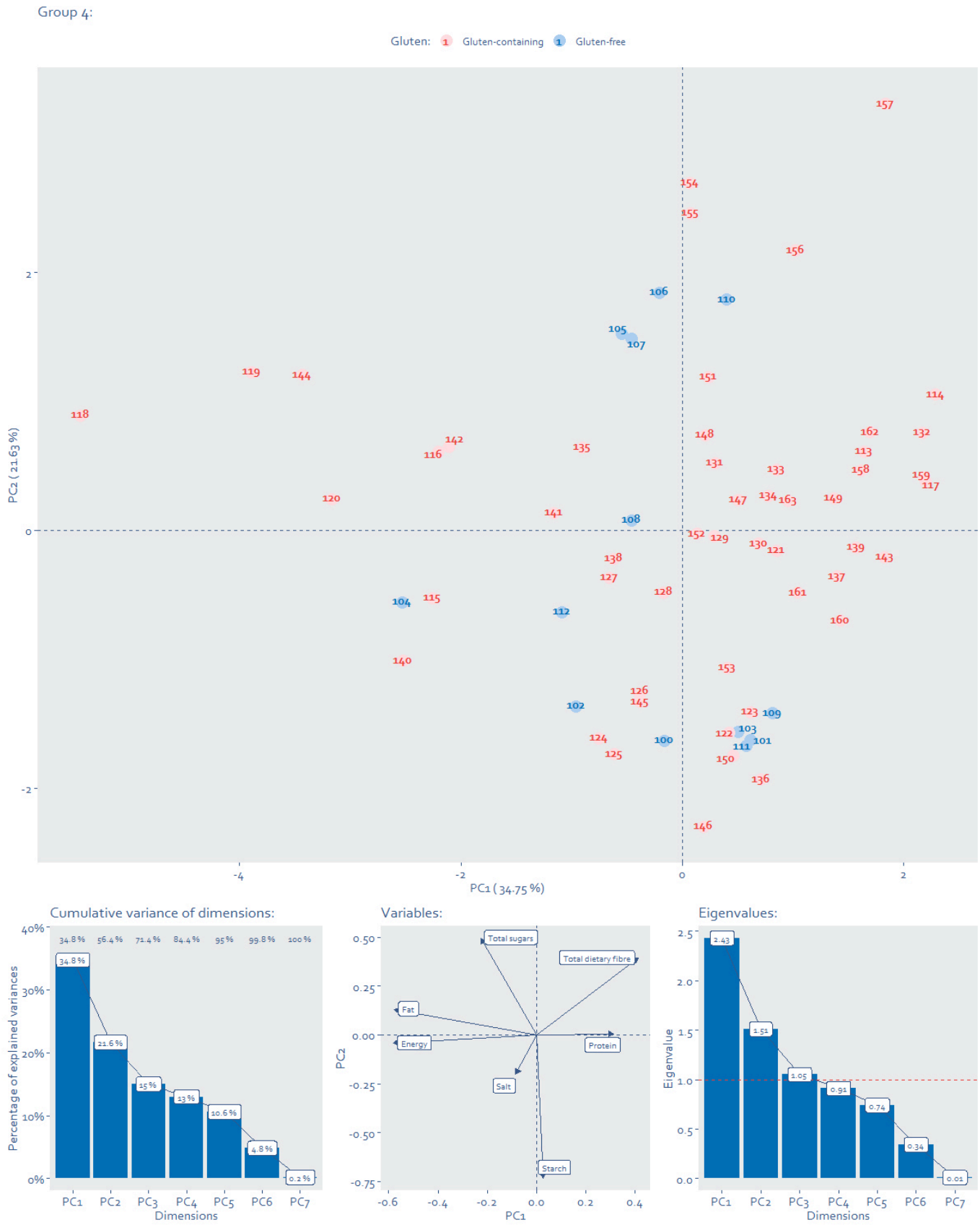

Figure 10. The major nutrients in breads and wraps (Category 4). PCA was performed on results in DW.

The PCA chart of the major nutrients in breads and wraps (see Figure 10) shows a general difference in the content of protein and total DF between gluten-containing and gluten-free products. Products rich in both protein and DF can be found in the upper right quadrant of the PCA chart. All but one of the products located there are gluten containing.

There are two gluten-containing products with higher levels of total sugar: sweetened wheat/rye loaves (PCA IDs 155 and 154). Furthermore, at the far left of the chart, four gluten-containing products (PCA IDs 118, 119, 120 and 144) stand out due to their high fat and energy content, all of which are salty biscuits/crackers.

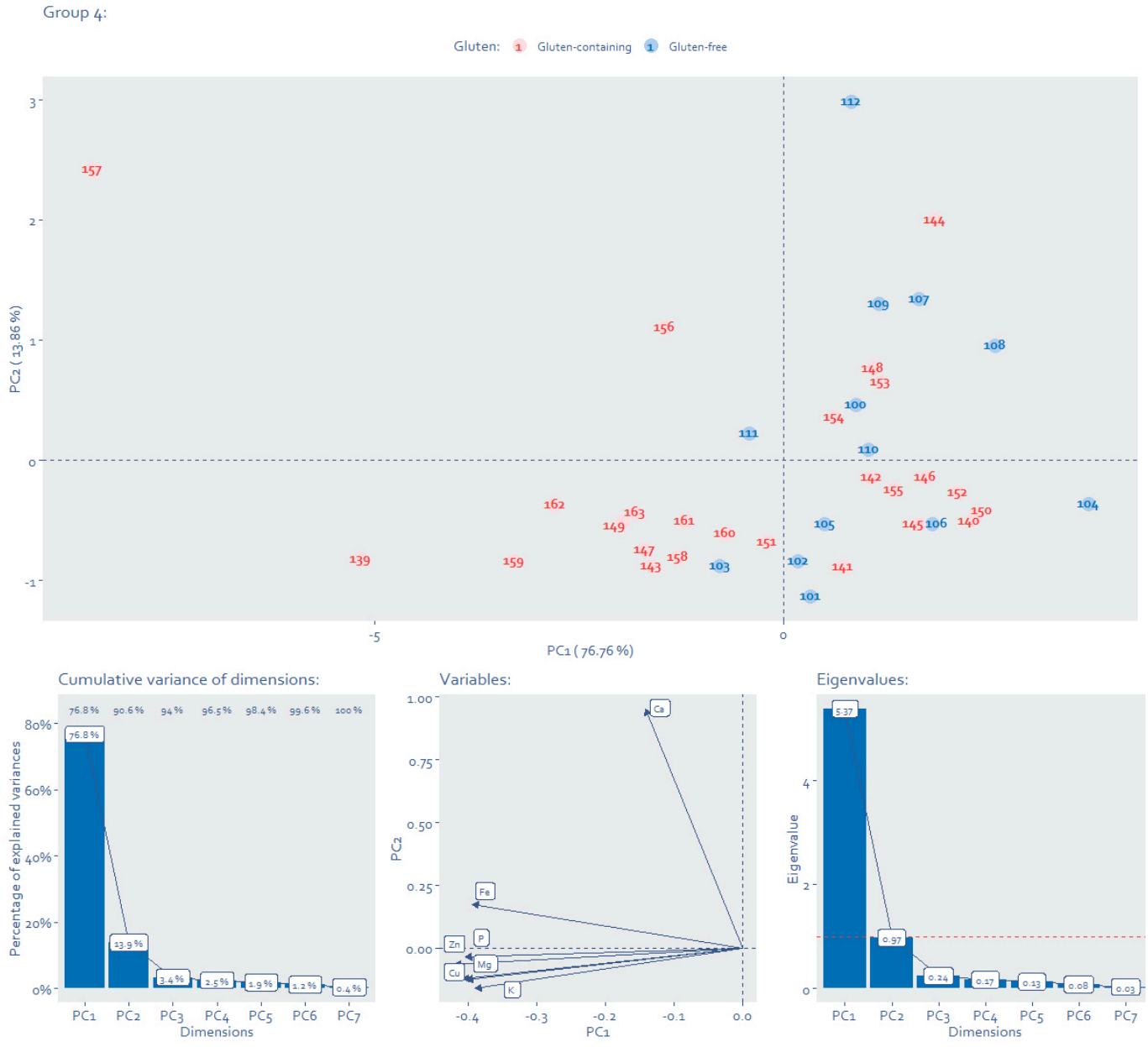

Figure 11. The minerals / essential elements in Category 4 (breads and wraps). PCA was performed on results in DW.

The crispbreads containing rye and wholegrain breads are found on the left side of the PCA chart in Figure 11, indicating more minerals, whereas the white breads contain less and are found on the right side of the PCA chart. PCA ID 157, placed in the upper-right corner of the PCA chart in Figure 10 and the upper-left corner of the PCA chart in Figure 11, contains the highest amount of total DF among the gluten-containing products: 24 g/100g FW. It is a wholegrain crispbread with sesame seeds, wheat bran and wheat sprouts. Wheat bran in particular is known to contain higher amounts of minerals and also cadmium (Jorhem et al., 2013).

As expected, tortilla bread wheat (PCA ID 146) and wholegrain wheat (PCA ID 147) are clearly differentiated from each other in the PCA according to the differences in mineral content.

In both Figures 11 and 12, the gluten-containing products show a higher content of the major essential elements among the products tested. The majority (11/13) of the gluten-free breads/wraps are situated on the right side of the PCA chart, indicating that these products to are poor in minerals; 12 of the 25 gluten-containing breads are on that side. At least based on the data from this study, it can be stated that gluten-free breads, on average, contain less minerals than gluten-containing breads.

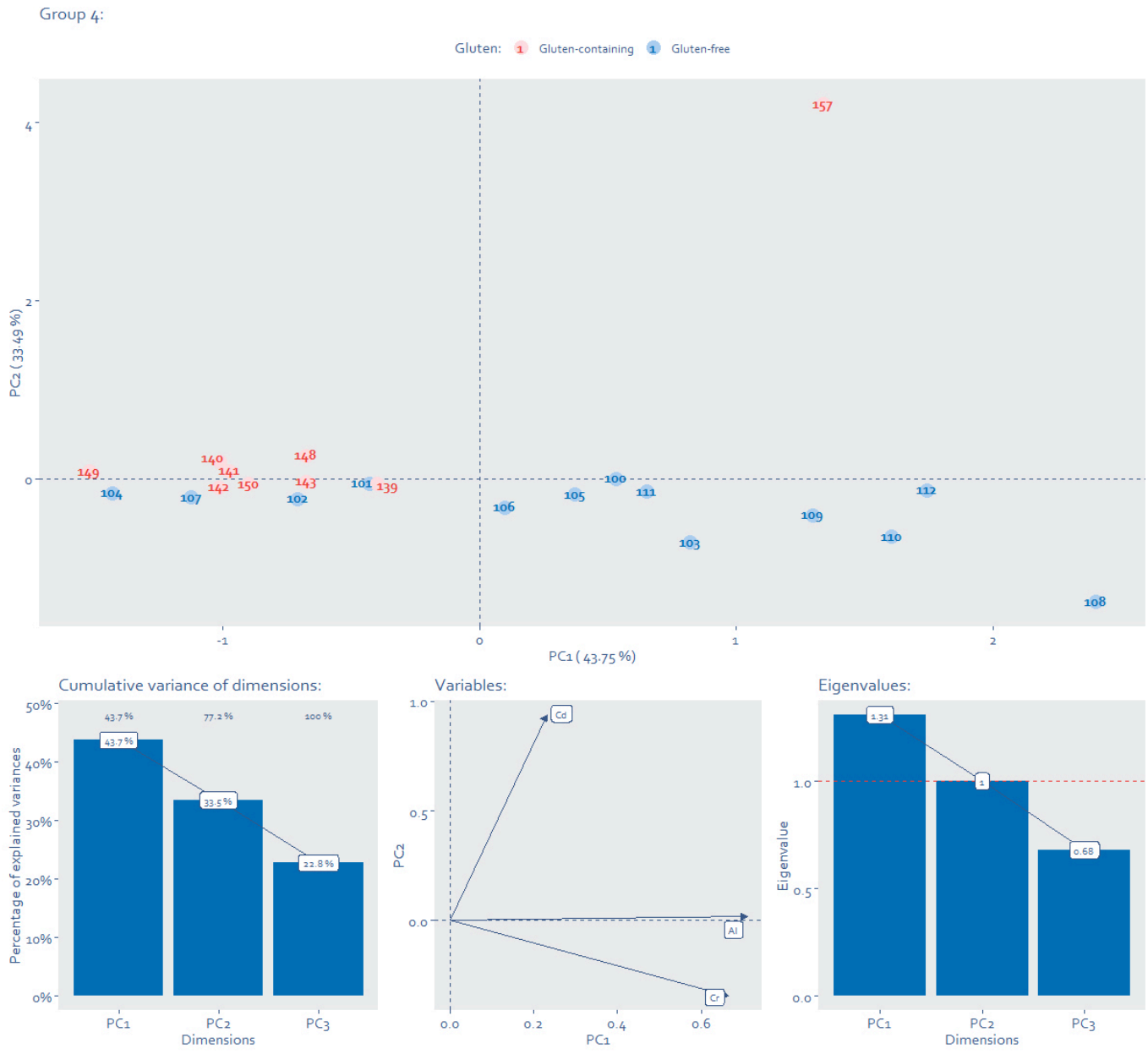

Figure 12. Cadmium, aluminium and chromium in Category 4 (breads and wraps). PCA was performed on results in DW.

In Figure 12, as well as in Figures 10 and 11, PCA ID 157 (shown in upper right corner of the PCA chart in Figure 12) stands out from the rest of the products due to the extraordinarily high cadmium content: 44 mg Cd/100g FW. As mentioned above, wheat bran is known to contain high levels of Cd, but the highest level found in 54 pure wheat bran samples tested by Jorhem et al. (2013) was 25 µg/100g (mean: 12 µg/100g FW). This indicates that the high Cd level in this crispbread (PCA ID 157) must have other ingredients with a high Cd content. This generic product also contains wholegrain rye flour, wheat sprouts and sesame seeds. Rye generally contains lower Cd levels than wheat (Jorhem et al., 2015), and in a seed mapping project carried out by the FFA in 2017, Cd levels in sesame seeds were 0.5–7.8 mg/100g FW. So, there is no completely satisfactory explanation for the high Cd level in

PCA ID 157. The gluten-free products show a higher content of Cr, which was also seen in the boxplot of Figure 3. No significant difference was found in Al content, but the range of results is wider in the gluten-free products (see Figure 4).

7.3.2.1. PCA and factor score analysis of Category 4 ('Breads and wraps')

As for Category 1, a detailed PC and factor score analysis was carried out for Category 4. Similarly, as with the Category 1 data, based on the preparatory analysis (with the eigenvalues of the PCs >1; see Figure 5), a four PC solution was picked for further analysis.

The four PC solution for Category 4, the labelling of the dimensions, the nutritional interpretation and information, and whether or not typical products contain gluten and nutrients that are associated with the identified patterns are presented in Table 11. The variance explained by these four PCs was 80%. The correlation matrix plot for the loadings of Category 4 is presented in Figure 13. Examples of the food items characterising the PC (factor score: >1.0) are presented in the Appendix, Table 4.2.

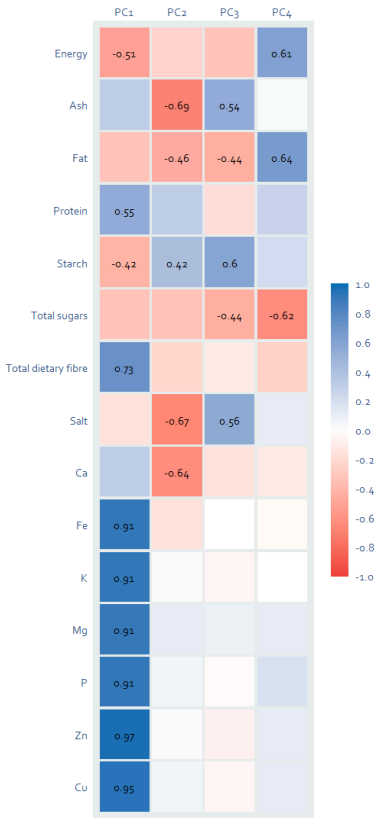

Figure 13. A generated PCA correlation matrix plot for the loadings in Category 4. Positive correlations are indicated in blue and negative in red. Loadings > 0.4 and < -0.4 are taken into account in the interpretations.

The first pattern (PC1) of the Category 4 foods, alone explaining 46% of the total variance, was mainly characterised by wholegrain, rye breads, both fresh and rye crispbread.

The nutrients associated with the PC1 of Category 4 were several minerals (e.g. zinc,

potassium, iron and magnesium), but characteristics were also both high fibre and protein content. The PC1 of 'Breads and wraps' was characterised as being low in energy and starch. All the examples of foods with factor scores >1 were gluten-containing products. This PC1 of 'Breads and wraps' showed quite the opposite nutrient- and gluten-content dimension when compared with the PC1 of Group 1 ('Flours and flakes'), which was characterised by gluten-free products, high in starch and energy, and low in several minerals.

The PC2 of 'Breads and wraps' was named as 'the wholegrain wheat-millet PC', associating with high starch content and low salt, calcium and fat content. This PC explained 14% of the total variance in the data. Only 20% of the typical products for this dimension were gluten free.

PC3 was characterised as correlating with high starch and salt content and negatively associated with fat and total sugars. The variance explained by this PC was 10%. Typical products of this PC3 were refined, salty, low-energy and low-fat breads. This dimension was more typical for gluten-free products with 63% of the typical products that had a factor score >1 being gluten-free products.

The fourth dimension, PC4, of Category 4 ('Breads and wraps') had a slight similarity to PC3, both being characterised by low total sugar content, but they were associated in an opposing manner in regard to fat content. PC4 was characterised by high-fat and high-energy content. Typical foods contained slightly differing types of products, ciabatta and Karelian pasty with rice filling being the products typically prepared with additional oil or butter. On the other hand, typical products of this dimension also included several dry savoury biscuits. Only 17% of the characteristic breads for this dimension were gluten free.

Table 11. The four-dimensional solution of the nutrient content of 100 g of food portions (the nutrient value solution): the factor loadings of the nutrients.

Dimension	PC1	PC2	PC3	PC4
Name	Wholegrain, rye crispbread factor	Wholegrain wheat-millet factor	Salty, low energy and fat breads factor	Energy- and fat-containing or dry biscuits
Nutritional interpretation	High in minerals, fibre and protein; low in energy and starch	High in starch; low in salt, calcium and fat	High in starch and salt; low in sugar and fat	High in fat and energy; low in sugar
Gluten free / gluten containing	Mainly gluten-containing products	Mainly gluten-containing products	Mainly gluten-free products	Mainly gluten-containing products
Variance explained (%) Total 79.7%	45.9	13.9	10.3	9.8
Loading	Zinc	Starch	Starch	Fat
>0.4	Copper		Salt	Energy
	Phosphorus		Ash	
	Potassium			
	Iron			
	Magnesium			
	Total DF			
	Protein			
<-0.4	Energy	Ash	Fat	Total sugars
	Starch	Salt	Total sugars	
		Ca		
		Fat		

In Category 4, the gluten-containing foods dominated in the foods with high factor scores. This pattern differed from the Category 1 foods where the typical foods of the different dimensions were more often gluten free. This analysis showed that gluten-free breads and wraps seemed to be more often refined and starch and salt containing compared with gluten-containing breads and wraps.

7.4 Descriptive analysis

The products in Categories 2 ('Cereal flakes'), 3 ('Muesli and granola') and 5 ('Waffle mix and cookies') were evaluated descriptively since they all contained too few products for separate category-based statistical analysis. However, all of these products (except those lacking nutritional values) were part of the PCA of all samples and therefore have PCA ID numbers.

7.4.1 Category 2: Cereal flakes

Category 2 contained only three gluten-free products which were compared to seven branded and five generic gluten-containing products. Some variation was observed within all major nutrients. Cereal flakes (PCA ID 74), corn flakes (PCA ID 75) and rye cereal (PCA ID 88) had energy values below 1600 kJ/100g DW (1470, 1530, 1570 kJ/100g DW, respectively). All the other cereal flakes in this group were higher in energy (1610–1760 kJ/100g DW). The abovementioned products contained less fat, sugar and starch, or a combination of these, than the rest of the products in this group, explaining the difference in energy content.

Special flakes (PCA ID 76) and corn flakes (PCA ID 75) that were labelled *gluten free*, and corn flakes categorised as a gluten-containing generic product (PCA ID 85) contained less Ca (8.3, 3.6 and 5.2 mg/100g DW, respectively) compared with the other products in this category where the Ca contents were 22–32 mg/100g DW. Also, the Cu, Mg, P and Zn contents were lower in the two types of corn flakes mentioned (the results in FWs are shown in Appendix 3). Data of non-essential elements is very limited, and comparison is not possible. More analytical results are needed.

7.4.2 Category 3: Muesli and granola

Category 3 only had three gluten-free products, six branded products and two generic products. Variation within the major nutrients was also found in this category. The two highest sugar contents (21 and 26 g/100g DW) were gluten-free products (muesli with fruit [PCA ID 89] and muesli with raisins and figs [PCA ID 90]), most likely due to the fruit used in the products, their quantity or quality.

Due to the small number of versatile products in this category, comparisons between the products are difficult. However, all three analysed gluten-free products contained slightly more As and Co and considerably higher amount of Ni than the gluten-containing products. Two of the gluten-free products (PCA IDs 89 and 90) also contained a nearly threefold amount of Al compared with the other products (see Appendix 3). There is no specific EU maximum Cd level for muesli, but the Cd content in gluten-free granola with blueberries, rhubarb, cardamom and cinnamon (PCA ID 91; 17 mg Cd/100g FW) did exceed the EU maximum level for cereals (excluding wheat), which is 10 µg/100g FW, but was still below the maximum level for wheat: 20 µg/100g FW. Note that the comparisons with EU maximum levels are only indicative for mixed products since the maximum levels can differ for different ingredients in the products. However, looking at the exposure for the regulated non-essential elements in general, the comparisons can contribute to the evaluation. Far-reaching conclusions from these observations alone should not be drawn because the number of products is very small.

7.4.3 Category 5: Waffle mix and cookies

Only one gluten-free waffle mix and one cookie product were included in this category. The other eight products in the category were: three branded gluten-containing waffle mixes (or pancake mixes), three types of cookie, one generic waffle and one generic cookie. As expected, the variation between products in this category was so great that even descriptive comparison was not possible.

7.4.4 Sugars

The individual sugars (fructose, galactose, glucose, sucrose, maltose, lactose) were analysed in this study from gluten-free products. Comparison of the individual sugar contents using statistical methods was not possible due to missing information on gluten-containing products. No surprises were seen in the sugar profiles, but interestingly, only two gluten-free samples contained lactose (PCA ID 15 [flour mix] and PCA 107 [wraps]). The Nordic FCDBs lack a significant number of sugar results for gluten-containing products. More individual sugar results are needed, but the biggest shortcomings are for galactose and lactose.

7.4.5 Dietary fibre

DF fractions were determined in 20 gluten-free products. However, as with sugars, specific contents of the DF fractions are not found in the Nordic databases to such an extent that the results could be compared statistically. The analytical results for the DF fractions are presented in Table 12 and in Appendix 2.

Table 12. The DF fractions analysed for gluten-free products. Results are expressed in g/100g FW.

Note: IDF = insoluble dietary fibre (polysaccharides); SDFP = water-soluble dietary fibre polysaccharides; SDFS = water-soluble dietary fibre oligosaccharides; total DF = total amount of dietary fibre, a sum of IDF + SDFP + SDFS; n.d. = not detected

PCA ID	Product description	IDF	SDFP	SDFS	Total DF
3	Corn flour, Risenta	4.1	0.7	1.0	5.8
5	Oat flour, wholegrain, gluten free, Viljatuote	7.0	6.9	0.3	14.2
7	Rice flour, Viljatuote	0.7	0.4	1.0	2.1
8	Teff flour, Oriola	4.4	3.0	n.d.	7.4
9	Sugar beet flakes, Fibrex	56.9	19.3	1.7	77.9
10	Maize groats, Risenta	5.6	0.8	0.8	7.2
11	Buckwheat flour, Risenta	2.5	2.3	0.7	5.5
12	Flour mix, coarse, gluten free, TORO	5.4	2.3	n.d.	7.7
13	Oat bread mix, gluten free, TORO	5.6	3.9	0.4	9.9
14	Flour mix, Finmix, Semper	1.2	12.8	3.2	17.1
15	Flour mix, Finax	0.0	2.0	1.5	3.5
74	Cereal flakes, gluten free, Schär	2.2	1.2	n.d.	3.4
76	Special flakes, fortified, gluten free, Semper	0.2	1.0	n.d.	1.2
89	Muesli with fruit, gluten free, Finax	18.4	6.5	0.2	25.1
100	Crispbread, gluten free, Pirkka	3.8	4.6	0.2	8.6
106	Wraps, gluten free, Schär	4.0	6.7	2.2	12.9
108	Dark loaf with linseed, gluten free, Fria Bröd	2.3	3.5	n.d.	5.8
109	Crisp bread with chia seeds, gluten free, Semper	6.7	3.5	n.d.	10.2
110	Sourdough bread, gluten free, Dr Schär	5.2	3.3	1.2	9.7
112	Crispbread with sesame seeds and sea salt, gluten free, Wasa	7.4	2.2	n.d.	9.6

The total DF content in the analysed gluten-free products varied widely, ranging from 1.2 g/100g FW in special flakes (PCA ID 76) to 77.9 g/100g FW in sugar beet flakes (PCA ID 9). The total DF contents of corn, rice, teff and buckwheat flour were 2.1–7.4 g/100g FW, whereas gluten-free wholegrain oat flour contained over two times more DF (14.2 g/100g FW). The total DF contents of wheat, rye and barley flours are between 3.5 and 19 g/100g FW (Tables 2.2 and 2.3, Appendix 2), of which the highest concentrations belong to wholegrain flours (11–19 g/100g). According to Fineli, the total DF contents of other gluten-free cereals and pseudo-cereals are: millet flour 3.2 g/100g, corn flour 1.9 g/100g, tapioca flour 0.9 g/100g, quinoa seeds 7.0 g/100g and amaranth flakes 6.7 g/100g (all expressed as FWs). The DF contents in these products are lower than commonly used gluten-containing wholegrain flours. Thus, the total DF content of most gluten-free cereals and pseudo-cereals is considerably lower than that of wholegrain wheat, rye and barley, which may lead to the use of other raw materials in gluten-free products in order to increase the DF content.

In general, in gluten-containing cereals, the highest portion of total DF (40–73%) is composed of IDF (see Tables 2.2 and 2.3, Appendix 2). The share of IDF is highest in wholegrain products, but in flours with small amounts of bran, the amount of IDF and water-soluble dietary fibre polysaccharides (SDFP) can be almost equal. The DF profiles were versatile in the different gluten-free products analysed. Corn flour (PCA ID 3) proportionally contained a similar amount of IDF, SDFP and oligosaccharides (70%, 1% and 18%, respectively) as wholegrain wheat flour (PCA IDs 45 and 57), but quantitatively, wheat flour has more than twice as much DF. The rice flour (PCA ID 7) contained a relatively small amount of IDF (33% of total DF) and a high proportion of oligosaccharides (48% of total DF), while teff flour (PCA ID 8) had no oligosaccharides at all. Sugar beet (PCA ID 9), which is high in DF, may be used to increase the DF content of gluten-free products. The concentrations of sugar beet IDF and SDFP were quite similar to those of cereals, although the amount of IDF (73% of total DF) is at the upper end of the range and the relative amount of oligosaccharides is very small (2% of total DF; see Table 10). In this study, only one sample of sugar beet was analysed, but considering the extreme levels of both non-essential elements (Cd and Pb) and essential elements (such as Cr and Mn, which can be toxic at too high levels), it is important to further evaluate the contributions from sugar beet in general.

7.4.6 Chemical elements not included in PCA

Some of the chemical elements had to be excluded from the PCA because of missing information in the FCDBs. The excluded essential elements were I and Se. Non-essential elements that could not be used in the statistical analyses of this study were As, Ag and Hg. More analytical values of these elements are needed in the databases.

8. Conclusions

The results from this project are based on a limited number of samples and may not be generalised to all gluten-free products. However, statistically significant differences were found between gluten-free and gluten-containing product groups. Some main conclusions can be drawn, and strategical proposals suggested on the basis of the data:

- Gluten-free products are a heterogenous group based on their nutrient composition, including basic foods (derivatives of single raw commodities) and composite foods (consisting of several ingredients). In composite foods, the main differences were based on ingredients other than cereal ingredients, such as milk powder, fats or fortification agents (e.g. iron).
- The gluten-free products contained significantly less protein, copper, potassium, phosphorus, zinc and manganese than the included gluten-containing products.
- The contents of starch and chromium were significantly higher in the gluten-free products than in the gluten-containing products.
- The levels of cadmium were similar in the gluten-free and gluten-containing products.
- The gluten-free products contained significantly higher levels of nickel and lead compared with the gluten-containing products. Most of the lead values were well below the EU maximum level (20 µg Pb/100 g for cereals), but there are currently no maximum levels for nickel.
- In the product development of gluten-free products, attention must be paid to the nutritional content and non-essential elements of the gluten-free ingredients in new products.

Are gluten-free products a healthier alternative? Considering the nutritional composition, gluten-free products are not healthier compared to similar gluten-containing products. In addition, the content of some heavy metals is higher in the gluten-free products studied.

The nutritional values of the gluten-free products analysed in the project will be added to FCDBs. For gluten-free raw materials in particular, the coverage of the Nordic FCDBs can be considered better after this project. However, since the non-essential elements such as As, Ag and Hg, and other non-wanted substances like mycotoxins, dioxin etc., are mostly not included in the Nordic FCDBs, there will still be a lack of data for risk-benefit assessment. In order to develop a long-term diet that sustains health, it is important to fill these gaps. Nordic FCDBs contain partially different nutrients in different units, and some nutrients are even calculated based on different factors. In particular, there is still a lack of results for individual sugars, dietary fibre fractions, I and Se. The need for harmonisation was already discussed in a previous Nordic co-operation project (the NordCoLa project) and is still seen as a factor that would facilitate co-operation in the future. Working together with the other Nordic countries is considered beneficial as the resources are shared and the results are for everyone to use.

References

Allied Market Research. (2020). https://www.alliedmarketresearch.com/gluten-free-products-market (accessed 1 December 2020).

Browaldh, L., Sandström, O., Agardh, D., Stenhammar, L. & Ivarsson, A. (2014). Celiaki är en vanlig sjukdom som är lätt att missa. *Läkartidningen*, 111 (11), 484–488.

Codex Alimentarius. (1979). Standards for foods for special dietary use for persons intolerant to gluten. CXS 118-1979. Adopted in 1979. Amended in 1983 and 2015. Revised in 2008.

Codex Alimentarius Commission. (2009). The Codex definition of dietary fibre. Alinorm 09/32/26.

EU (2014). Commission implementing regulation (EU) No 828/2014 on the requirements for the provision of information to consumers on the absence or reduced presence of gluten in food (2014). *Official Journal of the European Union*, L 228 (5-8).

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.

EC. (2017). Commission regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs. 02006R1881-EN-20201014

EFSA. (2010). Scientific opinion on lead in food. *EFSA Journal*, 8 (4), 1570, 1-151.

EFSA. (2012). Scientific opinion on cadmium in food. *EFSA Journal*, 10 (1), 2551, 1-37.
EFSA. (2012). Scientific opinion on the risk for public health related to the presence of mercury and methylmercury in food. *EFSA Journal*, 10 (12), 2985, 1-241.

EFSA. (2014). Scientific report of EFSA 'Dietary exposure to inorganic arsenic in the European population'. *EFSA Journal,* 12 (3), 3597, 1-68.

EFSA. (2014). Scientific opinion on the risks to public health related to the presence of chromium in food and drinking water. *EFSA Journal,* 12 (3), 3595, 1-261.

EFSA. (2015). Scientific opinion on the risks to public health related to the presence of nickel in food and drinking water. *EFSA Journal,* 13 (2), 4002, 1-202.

Euromonitor International. (2020). Free from Gluten Market Sizes & Free from Gluten H&W as % of total market reports. https://www.portal.euromonitor.com [accessed 23 November 2020].

Fennema, O.R. (ed.) (1996). *Food Chemistry*. New York, USA: Marcel Dekker, Inc., 3rd edition, p. 639.

Finnish Coeliac Society, (2020). https://www.keliakialiitto.fi/kuluttajat/keliakia/keliakia-sairautena/ (accessed 23. November 2020).

Finnish Food Authority (2017). Öljykasvien siementen kartoitus- ja valvontahanke - loppuraportti (in Eng. 'Oilseed mapping and control project – Final report').

Finnish Food Composition Database Fineli. www.fineli.fi

Helldán, A., Raulio, S., Kosola, M., Tapanainen H., Ovaskainen M.-L. & Virtanen, S. (2013). Finravinto 2012–tutkimus—The National FINDIET 2012 Survey. Report 16/

2013. Helsinki, Finland: National Institute for Health and Welfare.

ICA AB. (2018) Personal communication with Christina Karlsson.

Jorhem, L., Sundström, B. & Engman, J. (2013). Trends in Cadmium and Certain other Metal in Swedish Household Wheat and Rye Flours 1983–2009. Swedish Food Agency Report no 16/2013. ISSN 1104-7089.

Jorhem, L., Åstrand, C., Sundström, B., Engman, J. & Kollander, B. (2015). Spannmål, nötter och fröer. Metaller i livsmedel - fyra decenniers analyser (in Eng. 'Cereals, nuts and seeds: Metals in food – four decades of analysis'), Swedish Food Agency Report no 1/2015. ISSN 1104-7089.

Kollander, B. & Sundström, B. (2015). Inorganic arsenic in rice and rice products on the Swedish market 2015. Part 1: Survey, Swedish Food Agency Report no 16/2015. ISSN 1104-7089.

MarketsandMarkets. (2020) https://www.marketsandmarkets.com/Market-Reports/gluten-free-products-market-738.html (accessed 1 December 2020).

McCleary, B.V., Sloane, N. & Draga, A. (2015). Determination of total dietary fibre and available carbohydrates: a rapid integrated procedure that simulates in-vivo digestion. *Starch*, 67, 860–883.

McCleary, B.V. (2019). Total dietary fiber (CODEX Definition) in foods and food ingredients by a rapid enzymatic-gravimetric method and liquid chromatography: Collaborative study, first action 2017.16. *Journal of AOAC INTERNATIONAL*, 102 (1), 196–207.

Megazyme. (2020). Rapid Integrated Total Dietary Fiber Assay Procedure, K-RINTDF 01/20. AOAC Method 2017.16, ICC Draft Standard 185.

Myléus, A., Ivarsson, A., Webb, C., Danielsson, L., Hernell, O. & Högberg, L. (2009). Celiac disease revealed in 3% of Swedish 12-year-olds born during an epidemic. *Journal of Pediatric Gastroenterology and Nutrition*, 49 (2), 170–176.

Nordic Council of Ministers. (2006). Health, food and physical activity: Nordic Plan of Action on better health and quality of life through diet and physical activity. Series ANP 2006:745, p. 64.

Norwegian Celiac Society. (2020). https://ncf.no/hva-er-coliaki (accessed 3 December 2020).

Norwegian Food Composition Tables. www.matvaretabellen.no

Popp, A. & Mäki, M. (2019). Changing pattern of childhood celiac disease epidemiology: Contributing factors. *Frontiers in Pediatrics,* 7 (357), 1–16.

R Core Team. (2019). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Reportsanddata. (2019). https://www.reportsanddata.com/report-detail/gluten-free-products-market#utm_source=prnewswire&utm_medium=referral&utm_campaign=john16oct2019 (accessed 1 December 2020).

Schalk, K., Lexhaller, B., Koehler, P. & Scherf, K.A. (2017). Isolation and characterization of gluten protein types from wheat, rye, barley and oats for use as reference materials. *PLoS ONE,* 12 (2), e0172819. doi:10.1371/journal.pone.0172819

Sjögren Bolin, Y., Nälsén C. & Mattisson, I. (2020). Råd och information om intag av

gluten för barn upp till 3 år i relation till utveckling av celiaki. Livsmedelsverkets rapportserie. Uppsala, Sweden: Livsmedelsverket.

Suomi, J., Valsta, L., Suominen, K. & Tuominen, P. (2020). Risk assessment on the dietary heavy metal exposure and aluminium exposure of Finnish adults. Helsinki, Finland: Finnish Food Authority. DOI: 10.5281/zenodo.3772613.

Svenska Dagbladet. (2017). https://www.svd.se/fortsatt-uppsving-for-glutenfritt (accessed 1 December 2020).

Swedish Food Agency. (2017). Swedish Market Basket Survey 2015 – per capita-based analysis of nutrients and toxic compounds in market baskets and assessment of benefit or risk. Swedish Food Agency report no 26 (2017). Uppsala, Sweden:.

Swedish Food Agency. (2020). Unpublished results, Dnr 2016/00605 and 2081/2014.

Swedish Food Agency. (2020). Work documentation: Mapping of products prior to analysis projects 2017–2020.

Swedish Food Agency. (2020). Fullkorn (livsmedelsverket.se). https://www.livsmedelsverket.se/livsmedel-och-innehall/naringsamne/kolhydrater/fullkorn

Swedish Food Composition Database NFA. www.livsmedelsverket.se

Valsta, L., Kaartinen, N., Tapanainen, H., Männistö, S. & Sääksjärvi, K. (2018). Ravitsemus Suomessa–FinRavinto 2017 –tutkimus —The National FINDIET 2017 Survey. Report 12/2018. Helsinki, Finland: National Institute for Health and Welfare.

Warensjö Lemming, E., Moraeus, L., Petrelius Sipinen, J. & Lindroos, A.K. (2018). Riksmaten ungdom 2016-17. Näringsintag och näringsstatus bland ungdomar i Sverige. (in Eng. 'Riksmaten adolescents 2016–17 nutrient intake and assessment of the nutrient intake adolescents in Sweden'). Uppsala, Sweden: Livsmedelsverket.

Wickham, H., Averick, M., Bryan, J., Chang, W., McGowan, L., François, R., Grolemund, G., Hayes, A., Henry, L., Hester, J., Kuhn, M., Pedersen, T., Miller, E., Bache, S., Müller, K., Ooms, J., Robinson, D., Seide,l D., Spinu, V., Takahashi, K., Vaughan, D., Wilke, C., Woo, K. & Yutani H. (2019). Welcome to the tidyverse. *Journal of Open Source Software*, 4 (43), https://doi.org/10.21105/joss.01686

Totland, T.H., Melnæs, B.K., Lundberg-Hallen, N., Helland-Kigen, K.M., Myhre, J.B., Johansen, A.M.W., Løken, E.B. & Andersen, L.F. (2012). Norkost 3, En landsomfattende kostholdsundersøkelse blant menn og kvinner i Norge i alderen 18–70 år, 2010–11. Helsedirektoratet.

Nordic summaries

Suomenkielinen yhteenveto: Ovatko gluteenittomat tuotteet terveellisempi vaihtoehto?

Tämä raportti kuvaa työtä, joka tehtiin projektissa "Ovatko gluteenittomat tuotteet terveellisempi vaihtoehto? Pilottitutkimus tehtiin ravintoaineista ja raskasmetalleista vuosina 2017–2020. Ensisijaisena tavoitteena oli parantaa tietoa tärkeiden ravintoaineiden ja raskasmetallien pitoisuuksista gluteenittomissa tuotteissa.

Gluteenittomien tuotteiden näytteet kerättiin Suomessa, Norjassa ja Ruotsissa. Ravintoaineita ja raskasmetalleja analysoitiin 37 gluteenittomasta tuotteesta, mukaan lukien jauhot, hiutaleet, mysli, leipä ja keksit. Määritetyt ravintoaineet olivat kosteus, tuhka, typpi, kokonaisrasva, tärkkelys, sokerit ja ravintokuitu. Analysoidut välttämättömät alkuaineet eli kivennäisaineet olivat: kalsium, koboltti, kupari, kromi, rauta, jodi, kalium, magnesium, mangaani, molybdeeni, fosfori, seleeni ja sinkki. Lisäksi arseeni, hopea, alumiini, kadmium, elohopea, nikkeli ja lyijy määritettiin raskasmetalleista tai ei-välttämättömistä alkuaineista.

Gluteenittomien tuotteiden lisäksi vertailuun valittiin tavanomaiset, vastaavaan käyttöön sopivat elintarvikkeet, joista suurin osa sisälsi luontaisesti gluteenia. Gluteenia sisältävät elintarvikkeet olivat joko verkkokauppojen tuotemerkkituotteita tai yleisiä tuotteita elintarvikkeiden koostumustietokannoista. Vertailuun valittiin yhteensä 136 gluteenia sisältävää tuotetta, joiden tiedot ravintoaineista ja raskasmetalleista eivät olleet kuitenkaan yhtä kattavia kuin analysoiduissa gluteenittomissa tuotteissa. Tuotemerkkituotteista oli saatavilla vain pakolliset merkinnät, kuten energia, rasva, tyydyttyneet rasvahapot, kokonaishiilihydraatit, sokerit, proteiini ja suola. Yleisten elintarvikkeiden osalta enemmän tietoa oli saatavilla, mutta arvot joillekin yksittäisille sokereille, yksittäisille ravintokuitufraktioille tai joillekin alkuaineille puuttuivat. Gluteenittomien tuotteiden ravintoaineiden ja raskasmetallien arvoja verrattiin gluteenia sisältävien ("tavanomaisten") tuotteiden arvoihin pääkomponenttianalyysilla (PCA). PCA:ta varten kaikki tulokset muunnettiin kuivapainoksi tuotteiden vertailun helpottamiseksi. Tuotteet myös jaettiin viiteen luokkaan karkeasti niiden käytön, jalostusasteen ja energiapitoisuuden perusteella, jotta eroja voitiin tutkia tarkemmin gluteenittomien ja gluteenia sisältävien tuotteiden välillä. Luokat olivat: 1) jauhot ja hiutaleet (raaka-aineet), 2) viljahiutaleet (jalostetut, useita aineosia), 3) mysli ja granola, 4) leivät ja wrapit, 5) vohvelijauhoseokset ja keksit. Kolme tuotetta jätettiin pois PCA:sta, koska ne poikkesivat liikaa muista tiedoista eivätkä edustaneet valittua ryhmää. Lisäksi yksittäisiä sokereita ja kuitufraktioita ei käytetty PCA:ssa puuttuvien tietojen vuoksi. Jodi, seleeni, arseeni, hopea ja elohopea oli myös suljettava pois PCA:sta liian monien puuttuvien arvojen vuoksi.

Tämän projektin tulokset perustuvat rajoitettuun määrään näytteitä, eikä niitä voida yleistää kaikkiin gluteenittomiin tuotteisiin. Tilastollisesti merkitseviä eroja löydettiin gluteenittomien ja gluteenia sisältävien tuotteiden välillä. Joitakin tärkeimpiä johtopäätöksiä tai ehdotuksia voidaan kuitenkin tehdä analysoituun aineistoon viitaten:

- Gluteenittomat tuotteet ovat ravintokoostumukseltaan hajanainen ryhmä, mukaan lukien peruselintarvikkeet (yksittäisten raaka-aineiden jalosteet) ja ruokalajit (useiden raaka-aineiden jalosteet). Ruokalajeissa tärkeimmät erot perustuivat muihin kuin viljan ainesosiin, kuten maitojauheeseen, rasvoihin tai lisättyihin ravintoaineisiin (esim. rautaan).
- Gluteenittomat tuotteet sisältävät merkitsevästi vähemmän proteiinia, kuparia, kaliumia, fosforia, sinkkiä ja mangaania kuin gluteenia sisältävät tuotteet.
- Tärkkelyksen ja kromin pitoisuus oli gluteenittomissa tuotteissa merkitsevästi suurempi kuin gluteenia sisältävissä tuotteissa.
- Kadmiumpitoisuus ei eronnut gluteenittomien ja gluteenia sisältävien tuotteiden välillä.
- Gluteenittomat tuotteet sisälsivät merkitsevästi enemmän nikkeliä ja lyijyä kuin gluteenia sisältävät tuotteet. Lyijyn määrä alitti selvästi EU:n maksimirajan (viljoilla 20 µg Pb/100 g), mutta nikkelille maksimirajaa ei ole määritetty EU:ssa.
- Gluteenittomien tuotteiden tuotekehityksessä on kiinnitettävä huomiota uusien tuotteiden gluteenittomien ainesosien ravintosisältöön ja ei-välttämättömiin aineosiin.

Ovatko gluteenittomat tuotteet terveellisempi vaihtoehto? Ravintosisältö huomioon ottaen gluteenittomat tuotteet eivät ole terveellisempiä verrattuna vastaaviin gluteenia sisältäviin tuotteisiin. Lisäksi joidenkin raskasmetallien pitoisuus on suurempi tutkituissa gluteenittomissa tuotteissa.

Projektissa analysoitujen gluteenittomien tuotteiden ravintoarvot lisätään elintarvikkeiden koostumustietokantoihin. Erityisesti gluteenittomien raaka-aineiden osalta pohjoismaisten koostumustietokantojen kattavuutta voidaan pitää parempana projektin ansiosta. Koska ei-välttämättömiä alkuaineita, kuten arseenia, hopeaa ja elohopeaa tai muita vierasaineita, kuten mykotoksiineja tai dioksiinia, ei kuitenkaan sisälly pohjoismaisiin koostumustietokantoihin, niin tietojen puute haittaa riski-hyötyarviointia. Kestävän ruokavalion kehittämiseksi pitkällä aikavälillä ei voida tarpeeksi korostaa ei-välttämättömien alkuaineiden merkitystä. Pohjoismaiset koostumustietokannat sisältävät osittain erilaisia ravintoaineita eri yksiköissä ja jotkut ravintoaineet lasketaan jopa eri tekijöiden perusteella. Tuloksista puuttuvat edelleen erityisesti yksittäiset sokerit, kuitufraktiot, jodi ja seleeni. Yhdenmukaistamisen tarpeesta keskusteltiin jo edellisessä pohjoismaisessa yhteistyöhankkeessa (NordCoLa), ja sitä pidetään edelleen tekijänä, joka helpottaa tulevaa yhteistyötä. Pohjoismainen yhteistyö on hyödyllistä, koska resurssit ja tulokset ovat kaikkien käytettävissä.

Norsk sammendrag: Er glutenfrie produkter et sunnere alternativ?

I denne rapporten beskrives arbeidet som ble gjennomført i prosjektet "Are gluten-free products a healthier alternative? A pilot study on nutrients and heavy metals", i perioden 2017 til 2020. Målet med prosjektet var å øke kunnskapen om innholdet av viktige næringsstoffer og tungmetaller i glutenfrie produkter.

Uttak av glutenfrie produkter til analyse ble gjort i Finland, Norge og Sverige. Næringsstoffer og tungmetaller ble analysert i 37 glutenfrie produkter, inkludert mel, frokostkorn, brød og kjeks og kaker. Følgende stoffer ble analysert: væskeinnhold, aske, nitrogen, fett, stivelse, sukker og kostfiber. Analyserte mineraler inkluderte kalsium, kobolt, kobber, krom, jern, jod, kalium, magnesium, mangan, molybden, fosfor, selen og sink. I tillegg ble produktene også analysert for arsen, sølv, aluminium, kadmium, kvikksølv, nikkel og bly.

I tillegg til de glutenfrie produkter, innhentet man informasjon om et utvalg av tilsvarende produkter, de fleste med naturlig inneholdende gluten, for sammenligning. Produktene med gluten var enten produkter fra nettbutikker, eller generiske produkter. Informasjon om disse produktene ble innhentet henholdsvis fra online produktdeklarasjoner og fra matvaredatabaser (generiske produkter). Til sammen ble 136 produkter med gluten valgt ut for sammenligning, men informasjonen om næringsstoffinnhold og innholdet av tungmetaller var ikke like omfattende for disse produktene som for de analyserte glutenfrie produktene. For produktspesifikke matvarer var bare deklarerte verdier for næringsstoffer tilgjengelig (energi, fett, mettet fett, karbohydrater, sukker, protein og salt). For generiske produkter var mer data tilgjengelig men verdier for noen individuelle sukkerarter, spesifikke kostfiberfraksjoner og noen mineraler manglet.

Næringsstoffverdiene og verdiene for tungmetaller i de glutenfrie produktene ble sammenlignet med tilsvarende verdier for glutenholdige produkter gjennom PCA-analyser. Alle resultater ble konvertert til mengder i tørr vekt av produktene for å tilrettelegge for sammenligning mellom ulike produkter. Produktene ble også delt inn i 4 kategorier, basert på deres bruksområder, nivå av prosessering og energiinnhold. Dette for å bedre å kunne sammenligne i detalj glutenfrie og glutenholdige matvarer. Kategoriene var: 1) mel og korn (i rå form); 2) frokostkorn (prosessert, flere ingredienser); 3) müsli og granola; 4) brød og wraps; 5) vaffelmix og cookies. Tre produkter ble ekskludert fra PCA-analysene på grunn av avvikende verdier fra de andre produktene, og derfor ikke representerte noen av kategoriene. På grunn av manglende verdier ble individuelle sukkerarter og kostfiberfraksjoner ikke inkludert i analysene. Verdier for jod, selen, arsen, sølv og kvikksølv ble også ekskludert fra analysene på grunn av manglende verdier.

Resultatene fra dette prosjektet er basert på et begrenset antall prøver og er derfor ikke generaliserbare til alle glutenfrie produkter. Det ble funnet noen statistisk signifikante forskjeller mellom glutenfrie og glutenholdige produkter. Basert på resultatene har prosjektet følgende konklusjon og strategiske forslag:

- Glutenfrie produkter er en heterogen gruppe produkter når det kommer til næringsstoffinnhold, for både basis-matvarer og sammensatte matvarer (matvarer med flere ingredienser). I sammensatte matvarer kom de største forskjellene i næringsstoffinnhold av andre ingredienser enn korn, slik som melkepulver og fett og av berikning (for eksempel med jern).
- De glutenfrie produktene inneholdt signifikant mindre protein, kobber, kalium, fosfor, sink og mangan enn de inkluderte glutenholdige produktene.
- Innholdet av stivelse og krom var signifikant høyere i de glutenfrie produktene enn i de glutenholdige.
- Nivåene av kadmium var like i de glutenfrie og de glutenholdige produktene.
- De glutenfrie produktene inneholdt signifikant høyere nivåer av nikkel og bly sammenlignet med de glutenholdige produktene. De fleste verdiene for bly var godt under EU maksimumsnivå (20 mg/100 g for korn). Det er per i dag ikke satt maksimumsnivåer for nikkel.
- I utviklingen av nye glutenfrie produkter bør man rette oppmerksomhet mot innholdet av næringsstoffer og ikke-essensielle elementer i de glutenfrie ingrediensene.

Er glutenfrie produkter et sunnere alternativ? Om man tar i betraktning sammensetningen av næringsstoffer så er glutenfrie produkter ikke sunnere enn tilsvarende glutenholdige produkter. I tillegg er innholdet av noen tungmetaller høyere i de glutenfrie produktene som ble undersøkt i dette prosjektet.

Resultatene fra analysene av de glutenfri produktene i dette prosjektet vil legges inn i matvaretabellene til landene som deltok i prosjektet. Prosjektet har bidratt til å øke kunnskapen og tilgjengelige data for glutenfrie produkter i Norden. Det er dessverre fortsatt manglende verdier for en del stoffer slik som As, Ag og Hg og andre ikke-ønskede stoffer som myko-toksiner og dioksiner, i de nordiske matvaretabellene. Det vil derfor fortsatt være data som mangler for risiko-nytte-analyser. For å utvikle langsiktige kosthold som underbygger en god helse er det viktig at disse kunnskapshullene lukkes. Nordiske matvaretabeller inneholder delvis ulike næringsstoffer, oppgitt i ulike enheter, og noen næringsstoffer er også estimert basert på ulike faktorer. Blant annet mangler det verdier for individuelle sukkerarter, kostfiberfraksjoner, I og Se. Behovet for harmonisering ble diskutert allerede i det forrige nordiske samarbeidsprosjektet om matvaretabellarbeid (NordCola) og er fortsatt en faktor som, dersom utbedret, vil legge til rette for samarbeid i fremtiden. Samarbeid mellom de nordiske landene er fordelaktig da ressursene deles og resultatene er tilgjengelige for alle.

Svensk sammanfattning Är glutenfria produkter ett hälsosammare alternativ?

I denna rapport beskrivs projektet "Är glutenfria produkter ett hälsosammare alternativ?". Syftet med projektet var att förbättra kunskapen om glutenfria produkter och deras innehåll av näringsämnen och tungmetaller.

Provtagning av glutenfria produkter utfördes i Finland, Norge och Sverige. Näringsämnen och tungmetaller analyserades i 37 glutenfria produkter inklusive mjöl, spannmålsflingor, müsli, bröd och kakor. Halter av följande ämnen analyserades:

- Makronäringsämnen: vatten (torrvikt), kolhydrater, fiber, stärkelse, socker, protein (kväve), fett och aska.
- Mikronäringsämnen: kalcium, kobolt, koppar, krom, järn, jod, kalium, magnesium, mangan, molybden, fosfor, selen och zink.
- Oönskade grundämnen inklusive tungmetaller: arsenik, silver, aluminium, kadmium, kvicksilver, nickel och bly.

Halterna av näringsämnen och tungmetaller i de glutenfria produkterna jämfördes med gluteninnehållande produkter med liknande användningsområden. Dessa var antingen märkesprodukter från nätbutiker eller generiska produkter från nationella livsmedelsdatabaser. Totalt valdes 136 gluteninnehållande produkter ut för jämförelser, dock var informationen om näringsämnen och tungmetaller inte lika omfattande som för de glutenfria produkterna. För märkesprodukter fanns endast obligatorisk märkningsinformation tillgänglig (energi, fett, mättade fettsyror, totala kolhydrater, sockerarter, protein och salt). För generiska livsmedel saknades värden för vissa enskilda sockerarter, fiberfraktioner och vissa mineraler/metaller.

De glutenfria produkternas innehåll av näringsämnen och tungmetaller jämfördes med värdena för motsvarande produkter med gluten genom så kallad PCA-analys (principal komponent analys). PCA-analyserna utfördes på halter i torrvikt för att underlätta jämförelser mellan olika produkter. Produkterna delades in i fem kategorier utifrån deras användningsområde, bearbetningsnivå och energiinnehåll, för att bättre undersöka skillnaderna mellan glutenfria produkter och produkter med gluten. Kategorierna var följande: 1) Mjöl och flingor (enskilda råvaror); 2) Spannmålsflingor (bearbetade, flera ingredienser); 3) Müsli och granola; 4) Bröd och wraps; 5) Våffelblandning och kakor.

Tre produkter uteslöts från analyserna eftersom de skilde sig för mycket åt och inte representerade den valda gruppen. På grund av de uppgifter som saknades, användes dessutom inte enskilda sockerarter och fiberfraktioner i PCA-analyserna. Även jod, selen, arsenik, silver och kvicksilver uteslöts från PCA-analyserna på grund av alltför få värden.

Resultaten från detta projekt baseras på ett begränsat antal glutenfria produkter (37 st) och kan inte generaliseras till alla glutenfria produkter. I studien framkom vissa statistiskt signifikanta skillnader mellan glutenfria produkter och produkter innehållande gluten. Baserat på resultaten så kan följande slutsatser dras och strategiska förslag föreslås:

- Glutenfria produkter är en heterogen grupp livsmedel baserad på deras sammansättning inklusive baslivsmedel (derivat av enskilda råvaror) och sammansatta livsmedel (flera ingredienser). I sammansatta livsmedel baserades de viktigaste skillnaderna på andra ingredienser än spannmål, såsom mjölkpulver, fetter eller berikningsmedel (t.ex. järn).
- De glutenfria produkterna innehöll signifikant mindre protein, koppar, kalium, fosfor, zink och mangan än de produkter som innehöll gluten.
- Innehållet av stärkelse och krom var signifikant högre i glutenfria produkter än i gluteninnehållande produkter.
- Kadmiumhalterna låg på samma nivåer i glutenfria och gluteninnehållande produkter.
- De glutenfria produkterna innehöll signifikant högre halter av nickel och bly jämfört med gluteninnehållande produkter. Halterna av bly låg till största delen under EUs gränsvärde för bly i spannmål (20 µg Pb/100 g). För nickel saknas det i dagsläget gränsvärden inom EU.
- I produktutveckling av glutenfria produkter rekommenderas att fokus förutom på näringsinnehållet i stort, även ligger på de näringsämnen som inte är obligatoriska, samt på de oönskade ämnen som de glutenfria ingredienserna kan innehålla.

Är glutenfria produkter ett hälsosammare alternativ? Med tanke på näringssammansättningen kan man inte säga att glutenfria produkter är hälsosammare än liknande produkter som innehåller gluten. Dessutom är innehållet av vissa tungmetaller högre i de glutenfria produkter som studerats.

Näringsvärdena för de glutenfria produkterna som analyserats i projektet kommer att läggas till i de nationella livsmedelsdatabaserna. Efter detta projekt kommer täckningen av glutenfria råvaror i de nordiska livsmedelsdatabaserna att ha förbättrats. Det kommer dock fortfarande att saknas uppgifter som kan vara viktiga för risk-nyttovärderingar då det i flera av de Nordiska livsmedelsdatabaserna saknas värden för oönskade ämnen som tungmetaller, mykotoxiner och dioxiner. Att fylla dessa luckor anses vara av stor vikt för arbetet med hållbara matvanor.

Utbudet av näringsämnen och metaller skiljer sig därtill åt i de Nordiska livsmedelsdatabaserna. Det förekommer också att det används olika enheter, faktorer och beräkningar. I alla databaserna ses en brist på data för enskilda sockerarter, fiberfraktioner, jod och selen. Behovet av en harmonisering diskuterades redan i ett tidigare nordiskt samarbetsprojekt (NordCoLa) och ses fortfarande som en faktor som skulle underlätta samarbetet i framtiden. Att arbeta tillsammans med de övriga nordiska länderna anses vara fördelaktigt eftersom resurserna delas och resultaten är till nytta för alla.

Appendix 1. Product information

Product PCA ID numbers, product types and product names (both in their original languages and in English) are listed in Tables 1.1–1.5. Gluten-free products were sampled from the stores and analysed. Values for branded products were found from the packages' nutritional information (for gluten-containing products that are not labelled as *gluten free*). Information on generic products were taken from the FCDBs.

Table 1.1. Category 1: Flours and flakes.

PCA ID	Original product name	Description in English	Type of product
1	Glutenfri bullemjölmix	Bun flour mix, gluten free, Viljatuote	Gluten-free product
2	Provena glutenfritt bakmjöl med havre	Baking flour with oats, gluten free, Provena	Gluten-free product
3	Majsmjöl	Corn flour, Risenta	Gluten-free product
4	Bovetemjöl	Buckwheat flour, Keskisen Mylly	Gluten-free product
5	Viljatuote Fullkornhavremjöl, glutenfri	Oat flour, wholegrain, gluten free, Viljatuote	Gluten-free product
6	Viljatuote Karkea bovetemjöl	Buckwheat flour, coarse, Viljatuote	Gluten-free product
7	Viljatuote Hieno rismjöl	Rice flour, Viljatuote	Gluten-free product
8	Teff-mjöl	Teff flour, Oriola	Gluten-free product
10	Risenta Majsgryn	Maize groats, Risenta	Gluten-free product
11	Risenta "Bovetemjöl"	Buckwheat flour, Risenta	Gluten-free product
12	TORO Melblanding grov glutenfri	Flour mix, coarse, gluten free, TORO	Gluten-free product
13	TORO Havrebrød mix glutenfri	Oat bread mix, gluten free, TORO	Gluten-free product
14	Semper "Finmix"	Flour mix, Finmix, Semper	Gluten-free product
15	Finax "Mjölmix"	Flour mix, Finax	Gluten-free product
16	Myllyn Paras Risflinga	Rice flakes, Myllyn Paras	Gluten-free product
17	Myllyn Paras Karkea vehnäjauho	Wheat flour, coarse, Myllyn Paras	Branded product
18	Sunnuntai Karkea vehnäjauho	Wheat flour, coarse, Sunnuntai	Branded product
19	Myllyn Paras Durumvehnäjauho	Durum wheat flour, Myllyn Paras	Branded product
20	Myllyn Paras Emännän puolikarkea vehnäjauho	Wheat flour, semi-coarse, Emännän, Myllyn Paras	Branded product
21	Kotimaista Puolikarkea vehnäjauho	Wheat flour, semi-coarse, Kotimaista	Branded product
22	Sunnuntai Täysjyvävehnäjauho	Wheat flour, wholegrain, Sunnuntai	Branded product
23	Myllärin Luomu täysjyvävehnäjauho	Wheat flour, wholegrain, Myllärin Luomu	Branded product
24	Myllyn Paras Graham täysjyvävehnäjauho	Wheat flour, wholegrain, Graham, Myllyn Paras	Branded product
25	Myllyn Paras Hiivaleipäjauho	Yeast bread flour, Myllyn Paras	Branded product

26	Myllyn Paras Ohrajauho	Barley flour, Myllyn Paras	Branded product
27	Kinnusen Mylly Ohrajauho	Barley flour, Kinnusen Mylly	Branded product
28	Kinnusen Mylly Ruisjauho	Rye flour, Kinnusen Mylly	Branded product
29	Kinnusen Mylly Ruissihtijauho rukiin sisemmistä osista	Rye flour, from the inner parts of rye, Kinnusen Mylly	Branded product
30	Pirkka Ruisjauho	Rye flour, Pirkka	Branded product
31	Myllyn Paras Korppujauhot	Flour, breadcrumbs, Myllyn Paras	Branded product
32	Myllyn Paras Mannasuurimo	Semolina, Myllyn Paras	Branded product
33	Pirkka Mannasuurimo	Semolina, Pirkka	Branded product
34	Kungsörnen vetemjöl	Wheat flour, Kungsörnen	Branded product
35	Favorit vetemjöl	Wheat flour, Favorit	Branded product
36	Kungsörnen grahamsmjöl	Wheat flour, graham, Kungsörnen	Branded product
37	Sammalt hvete, Møllerens	Wheat flour, wholegrain, Møllerens	Branded product
38	Møllerens Grovbakst hvete og rug	Flour mix, wheat and rye, Møllerens	Branded product
39	Møllerens 2 klassiske Havrebrød	Flour mix for oat bread, Møllerens	Branded product
40	Regal Havrebrød	Flour mix, oat bread, Regal	Branded product
41	Elovena Kaurahiutaleet	Oat flakes for porridge, Elovena	Branded product
42	Jauho, erikoisvehnäjauho, vähittäiskauppa	Wheat flour, coarse	Generic product
44	Flour, Wheat Flour, Semi-Coarse	Wheat flour, semi-coarse	Generic product
45	Jauho, täysjyvävehnäjauho	Wheat flour, wholegrain	Generic product
46	Jauho, korppujauho	Flour, breadcrumbs	Generic product
47	Mannasuurimo	Semolina	Generic product
48	Flour, Barley Flour	Barley flour	Generic product
49	Flour, Rye, Wholegrain Rye Flour	Rye flour, wholegrain	Generic product
50	Ruissihtijauho	Rye flour, fine	Generic product
51	Flour, Spelt Flour, Wholemeal	Spelt flour, wholegrain	Generic product
52	Jauho, täysjyvävehnäjauho	Wheat flour, wholegrain	Generic product
53	Flour, Tapioca (Very Low in Gluten)	Tapioca flour	Generic product
54	Flour Mixture, Rye, Wheat	Flour mix, rye and wheat	Generic product
55	Flour Mixture for Bread Rolls, Wheat Roll, Wheat Groats, Rye	Bun flour mix, wheat and rye	Generic product
56	Vetemjöl, unfortified	Wheat flour, unfortified	Generic product
57	Grahamsmjöl fullkorn vete	Wheat flour, wholegrain	Generic product
58	Barley Flour Whole	Barley flour, wholegrain	Generic product
59	Rye Wholegrain Flour	Rye flour, wholegrain	Generic product
60	Wheat Flour Durum	Wheat flour, durum	Generic product
61	Flour Mix Wheat Barley Rye Oat	Flour mix, wheat, barley, rye and oat flour	Generic product
62	Flour Mix Sifted Rye w/ Wheat	Flour mix, sifted rye and wheat flour	Generic product
63	Wholewheat Flour	Wheat flour, wholegrain	Generic product

64	Kaurahiutale	Oats, rolled, oat flakes	Generic product
65	Flour (unspecified)	Flour, unspecified	Generic product
66	Barley Flour, 50% Wholegrain	Barley flour, 50% wholegrain	Generic product
67	Oat Flour	Oat flour	Generic product
68	Rye Flour, Wholegrain	Rye flour, wholegrain	Generic product
69	Wholegrain Flour Mix	Flour mix, wholegrain	Generic product
70	Oat Grains	Oat grains	Generic product
71	Rice	Rice	Generic product
73	Wholegrain Mix, Rye (29%), Wheat (25%), Oat (25%) and Barley (21%).	Flour mix, wholegrain, rye, wheat, oat and barley	Generic product

Table 1.2. Category: Cereal flakes (processed)

PCA ID	Original product name	English name	Type of product
74	Schâr glutenfri Cereals Flakes	Cereal flakes, gluten free, Schär	Gluten-free product
75	Schâr glutenfri Corn Flakes	Corn flakes, gluten free, Schär	Gluten-free product
76	Semper "Specialflakes"	Special flakes, fortified, gluten free, Semper	Gluten-free product
77	Kellogg's Special K Classic	Special flakes, Kellogg's	Branded product
78	Fitness Frokost	Breakfast cereal, Fitness	Branded product
79	Kellogg's All Bran	Bran flakes, Kellogg's	Branded product
80	Kellogg's Corn Flakes	Corn flakes, Kellogg's	Branded product
81	Kellog's Special K	Special flakes, Kellogg's	Branded product
82	Favorit specialflingor berikade	Special flakes, fortified, Favorit	Branded product
83	Eldorado specialflingor berikade	Special flakes, fortified, Eldorado	Branded product
84	Cereal Mix	Cereal mix	Generic product
85	Cornflakes	Cornflakes	Generic product
86	Frukostflingor fullkorn berikade typ specialflingor	Breakfast cereal, wholegrain, fortified	Generic product
87	Breakfast Cereal Wholegrain, e.g. Special K	Breakfast cereal, wholegrain	Generic product
88	Rye Cereal	Rye cereal	Generic product

Table 1.3. Category: Muesli and granola

PCA ID	Original product name	English name	Type of product
89	Finax "Fruktmüsli"	Muesli with fruit, gluten free, Finax	Gluten-free product
90	Risenta "Russin & Fikon Müsli"	Muesli with raisins and figs, gluten free, Risenta	Gluten-free product
91	Orkla Foods "Pauluns Glutenfria Granola Blåbär, Rabarber, Kardemumma & Kanel"	Granola with blueberries, rhubarb, cardamom and cinnamon, gluten free, Paulún's, Orkla Foods	Gluten-free product
92	Axa F-musli frukt	Muesli with fruit, Axa F-musli	Branded product
93	Budget musli frukt	Muesli with fruit, Budget	Branded product
94	Salt å Kvarn fruktmusli	Muesli with fruit, Salt å Kvarn	Branded product
95	Frebaco Frukt och bär	Muesli with fruit and berries, Frebaco	Branded product
96	Risenta granola med kardemumma, blåbär, hasselnöt	Granola with cardamom, blueberries and hazelnut, Risenta	Branded product
97	Axa granola blåbär, dadlar, kardemumma	Granola with blueberries, dates and cardamom, Axa	Branded product
98	Breakfast Cereal Mix Wholegrain Muesli w/ Fruit	Muesli with fruit	Generic product
99	Frukostflingor müsli fullkorn m. frukt bär	Muesli with fruit and berries	Generic product

Table 1.4. Category: Breads and wraps

PCA ID	Original product name	English name	Type of product
100	Pirkka glutenfri knäckebröd	Crispbread, gluten free, Pirkka	Gluten-free product
101	Bio Zentrale Hirs-majskaka	Millet-corn cake, Bio Zentrale	Gluten-free product
102	Vuohelan, rispirog	Karelian pasty with rice filling, Vuohelan herkku	Gluten-free product
103	Glutenfri bovetebröd	Buckwheat bread, gluten free	Gluten-free product
104	Schär Glutenfri Salti	Crackers, gluten free, Schär Salti	Gluten-free product
105	Schär Glutenfri Ciabatta Rustica	Ciabatta, gluten free, Schär	Gluten-free product
106	Schär Glutenfri Wraps	Wraps, gluten free, Schär	Gluten-free product
107	Bfree glutenfri Wraps	Wraps, gluten free, Bfree	Gluten-free product
108	Fria Bröd "Fria Grova"	Dark loaf with linseed, gluten free, Fria Bröd	Gluten-free product
109	Semper "Superknäcke Chia"	Crispbread with chia, gluten free, Semper	Gluten-free product
110	Arvid Nordquist HB "Dr Schär Surdegsbröd"	Sourdough bread, gluten free, Dr Schär	Gluten-free product
111	Friends of Adam "Ljus surdeg"	Sourdough bread, gluten free, Friends of Adam	Gluten-free product
112	Wasa "Glutenfri & laktosfri sesam & havsssalt" (knäckebröd)	Crispbread with sesame seeds and sea salt, gluten free, Wasa	Gluten-free product
113	Vaasan Koulunäkki (Crispbread, Rye, 17% Fibre) FI	Rye crispbread, Koulunäkki, Vaasan	Branded product
114	Oululainen Hapankorppu FI	Rye crispbread, Finn Crisp, Oululainen	Branded product
115	Kantolan Cream Cracker FI	Water biscuit (Cream Cracker), Kantolan	Branded product
116	Fazer Rukiinen Imatran Riisipiirakka	Karelian pasty, Fazer	Branded product

117	Vaasan ruispalat	Rye bread, Vaasan	Branded product
118	Sætre Snackers salt	Salty biscuits, Sætre Snackers salt	Branded product
119	Ritz Crackers	Crackers, Ritz	Branded product
120	Tuc Kjeks Salt	Crackers, salt, Tuc	Branded product
121	Rema 1000 Ciabatta Grove	Ciabatta, coarse, Rema 1000	Branded product
122	Rema 1000 Ciabatta	Ciabatta, Rema 1000	Branded product
123	Eldorado Ciabatta steinovnsbakt	Ciabatta, baked in a stone oven, Eldorado	Branded product
124	Old El Paso Tortillas	Tortillas, Old El Paso	Branded product
125	Santa Maria Tortilla Original	Tortillas, original, Santa Maria	Branded product
126	Rema 1000 Tortillas	Tortillas, Rema 1000	Branded product
127	Old El Paso Tortillas Fullkorn	Tortillas, wholegrain, Old El Paso	Branded product
128	Santa Maria Tortilla Whole Wheat Medium	Tortillas, whole wheat, medium, Santa Maria	Branded product
129	Rema 1000 Fullkorntortillas	Tortillas, wholegrain, Rema 1000	Branded product
130	Skogaholm Fiberrost	Toast bread, Fiberrost, Skogaholm	Branded product
131	Pågen Rasker	Toast bread, Rasker, Pågen	Branded product
132	Wasa Din stund chia och havssalt	Crispbread with chia seeds and sea salt, Wasa	Branded product
133	Pågen Kärnsund surdegsbröd	Sourdough bread, Kärnsund, Pågen	Branded product
134	Pågen Lantgoda surdegsbröd	Sourdough bread, Lantgoda, Pågen	Branded product
135	Fazer Surdegsbröd eko	Sourdough bread, organic, Fazer	Branded product
136	Skogaholm Rustik levain	Sourdough bread, Skogaholm	Branded product
137	Fazer Bondens surdegsbröd	Sourdough bread, Fazer	Branded product
138	Wasa Knäckebröd med sesam och havssalt	Crispbread with sesame seeds and sea salt, Wasa	Branded product
139	Näkkileipä, ruisnäkkileipä, kuitua 17 %	Crispbread, rye, 17% fibre	Generic product
140	Cream Cracker Water Biscuit	Water biscuit, Cream Cracker	Generic product
141	Keksi, voileipäkeksi, ruis cracker, Kantolan	Water biscuit with rye flour, Cream cracker, Kantolan	Generic product
142	Karjalanpiirakka, rukiinen imatran riisipiirakka, Fazer	Karelian pasty, rice filling, Imatran, Fazer	Generic product
143	Ruisleipä, ruispalat, Vaasan	Rye bread, Vaasan	Generic product
144	Bisquits with salt	Salty biscuits	Generic product
145	Ciabatta	Ciabatta	Generic product
146	Tortilla Wheat	Tortilla, wheat	Generic product
147	Tortilla Wholewheat	Tortilla, wholegrain wheat	Generic product
148	Bröd vitt grovt m. nyckelhål typ formfranska	White bread, fibre rich	Generic product
149	Hårt bröd fullkorn råg fiber ca 20% typ sport	Crispbread, wholemeal, 20% fibre	Generic product
150	Bröd vitt typ levain	Sourdough bread	Generic product
151	Wheat and Rye Bread Sifted Flour c. 7% Fibre	Wheat and rye bread, 7% fibre	Generic product
152	Jättefranska	White bread, 5% fibre	Generic product
153	Baguette White Bread Wheat c. 2.5% Fibre	Baguette, 2.5% fibre	Generic product

154	Bread Wheat Rye Wholemeal c. 6% Fibre	Wheat and rye bread, Wholemeal bread, 6% fibre	Generic product
155	Pågenlimpan Skogaholmslimpa	White bread, loaf, 5% fibre	Generic product
156	Bread Wholemeal Rye c. 7% Fibre	Rye bread, wholemeal, 7% fibre	Generic product
157	Hårt bröd fullkorn råg m. sesamfrö vetekli vetegroddar fibrer 24%	Crispbread, wholemeal, rye, sesame seed, wheat bran, wheat sprouts, 24% fibre	Generic product
158	Crispbread Wholemeal Rye w/ Light Rye Flour c. 15% Fibre	Crispbread, wholemeal, rye, 15% fibre	Generic product
159	Bread, Wholegrain 75–100% A	Bread, wholegrain 75–100% A	Generic product
160	Bread, Wholegrain Spelt	Bread, wholegrain spelt	Generic product
161	Bread, Wholegrain 50–75%	Bread, wholegrain 50–75%	Generic product
162	Bread, Wholegrain 75–100% B	Bread, wholegrain 75–100% B	Generic product
163	Oat Bread	Oat bread	Generic product

Table 1.5. Category: Waffle mix and cookies

PCA-ID	Original product name	English name	Type of product
164	TORO Vafler mix glutenfri	Waffle mix, gluten free, TORO	Gluten-free product
165	Schär Glutenfri Coco chips Cookies	Chocolate-chip cookies, gluten free, Schär	Gluten-free product
166	Toro vafler mix	Waffle mix, TORO	Branded product
167	Pancakes ready-made, Myllyn Paras Pancake flour	Pancakes, ready-made, pancake flour, Myllyn Paras	Branded product
168	Pancakes ready-made, Mylly Paras Pancake flour + 10% butter for frying	Pancake flour + 10% butter for frying, Myllyn Paras	Branded product
169	Rema 1000 Cookies Choc Chip	Choc-chip cookies, Rema 1000	Branded product
170	Sæter Safari Original	Chocolate cookie	Branded product
171	Sætre CaféBakeriet Sjokoladeterapi	Chocolate cookie	Branded product
172	Waffles	Waffles	Generic product
173	Cookies	Cookies	Generic product

Appendix 2. Values for major nutrients and salt, in fresh weights

The major nutrient and salt values used in this study are presented in Tables 2.1–2.9 according to the product categories:

Tables 2.1–2.3:	Category 1, 'Flours and flakes' (divided into three tables for better readability)
Table 2.4:	Category 2, 'Cereal flakes'
Table 2.5:	Category 3, 'Muesli and granola'
Tables 2.6–2.8:	Category 4, 'Breads and wraps' (divided in three tables for better readability)

Each category contains **gluten-free**, **branded** and **generic products**. Gluten-free products were analysed in laboratories during this project. The nutritional information of the branded and generic products was collected from the product packages and Food Composition Databases (FCDBs).

n.a. = not analysed

n.d. = not detected

Glc = glucose; Gal = galactose; Fru = fructose; Suc = sucrose; Mal = maltose; Lac = lactose

Total sugars = Glc + Gal + Fru + Suc + Mal + Lac; Carb. = carbohydrates (total sugars + starch)

* = dietary fibre content was analysed from 20/40 gluten-free products. The values marked with an asterisk (*) are not analytical results but are declared on the product packages.

IDF = insoluble dietary fibre polysaccharides; SDFP = water-soluble dietary fibre polysaccharides; SDFS = water-soluble dietary fibre ligosaccharides; total DF = total amount of dietary fibre, a sum of IDF + SDFP + SDFS

- = value is missing /

LOQ values for major nutrients are presented in Table 6 of the report.

For branded products, the ash content has been calculated on the basis of sodium only because the concentrations of other elements were not available.

Table 2.1. Major nutrients. Category 1: 'Flours and flakes'. The results from analysis of **gluten-free products**. The energy unit is kJ, all the other nutrients are expressed as g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Gluten-free products																			
1	Bun flour_mix,gluten_free, Viljatuote	1467	0,69	11	1,1	6,0	78	0,070	<0,05	<0,05	0,27	<0,05	<0,05	0,34	78	n.a.	n.a.	n.a.	5,4*	0,014
2	Baking flour_with_oats, gluten_free,Provena	1402	1,0	12	0,27	2,8	76	0,050	<0,05	<0,05	3,5	<0,05	<0,05	3,6	79	n.a.	n.a.	n.a.	21*	0,60
3	Corn flour,Risenta	1542	0,75	12	2,3	6,0	76	0,19	<0,05	0,11	0,59	<0,05	<0,05	0,89	77	4,1	0,7	1,0	5,8	<LOQ
4	Buck-wheat_flour, Keskisen_Mylly	1384	1,7	10	<0,10	1,8	76	0,51	<0,05	0,26	3,1	0,14	<0,05	4,0	80	n.a.	n.a.	n.a.	5,0*	1,0
5	Oat flour,wholegrain, gluten_free,Viljatuote	1583	1,8	9	4,4	12	64	<0,05	<0,05	<0,05	0,68	0,11	<0,05	0,79	65	7,0	6,9	0,3	14	<LOQ
6	Buck-wheat_flour,coarse, Viljatuote	1436	2,7	10	3,7	18	58	0,17	<0,05	0,07	0,86	<0,05	<0,05	1,1	59	n.a.	n.a.	n.a.	5,9*	<LOQ
7	Rice flour,Viljatuote	1566	0,45	11	0,51	6,2	84	0,12	<0,05	<0,05	0,060	<0,05	<0,05	0,18	84	0,7	0,4	1,0	2,1	0,012
8	Teff flour,Oriola	1439	2,1	8	0,57	11	66	1,20	<0,05	0,49	0,96	0,16	<0,05	2,8	69	4,4	3,0	<0,2	7,4	0,0053
9	Sugar beet_flakes,Fibrex	1399	4,1	10	2,3	8,3	32	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	32	57	19	1,7	78	0,28
10	Maize groats,Risenta	1479	0,79	13	2,1	8,6	70	0,15	<0,05	0,10	0,48	<0,05	<0,05	0,73	70	5,6	0,8	0,8	7,2	<LOQ
11	Buck-wheat_flour, Risenta	1296	1,9	13	2,5	14	54	0,16	<0,05	<0,05	0,83	<0,05	<0,05	0,99	55	2,5	2,3	0,7	5,5	<LOQ
12	Flour mix,coarse,gluten_free, TORO	1654	2,0	6	4,0	5,0	76	4,2	<0,05	<0,05	0,23	<0,05	<0,05	4,4	80	5,4	2,3	<0,2	7,7	1,03
13	Oat bread_mix,gluten_free, TORO	1689	2,7	5	6,3	4,1	73	3,3	<0,05	<0,05	0,20	<0,05	<0,05	3,5	77	5,6	3,9	0,4	9,9	1,6
14	Flour mix,Finmix,Semper	1581	0,30	12	<0,10	2,0	80	<0,05	<0,05	<0,05	3,0	<0,05	<0,05	3,0	83	1,2	13	3,2	17	0,12
15	Flour mix,Finax	1445	0,78	11	<0,10	3,4	76	<0,05	<0,05	<0,05	0,050	<0,05	3,7	3,7	80	n.d.	2	1,5	3,5	0,093
16	Rice flakes,Myllyn_Paras	1554	0,41	12	0,31	6,6	84	0,10	<0,05	<0,05	0,15	<0,05	<0,05	0,25	84	n.a.	n.a.	n.a.	3,0*	<LOQ

Table 2.2. Major nutrients. Category 1: 'Flours and flakes'. **Branded products**. The nutritional information comes from the packages. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Branded products																			
17	Wheat flour,coarse, Myllyn_Paras	1460	0,010	13	1,6	13	68	-	-	-	-	-	-	0,40	68	-	-	-	4,0	0,010
18	Wheat flour,coarse, Sunnuntai	1500	-	12	2,1	12	70	-	-	-	-	-	-	0,50	70	-	-	-	4,0	-
19	Durum wheat_flour, Myllyn_Paras	1450	0,012	15	2,0	14	65	-	-	-	-	-	-	0,40	65	-	-	-	4,0	0,012
20	Wheat flour,semi-coarse, Emännän, Myllyn_Paras	1460	0,010	14	2,0	13	66	-	-	-	-	-	-	0,40	66	-	-	-	4,5	0,010
21	Wheat flour,semi-coarse, Kotimaista	1496	-	13	2,1	12	70	-	-	-	-	-	-	0,50	70	-	-	-	3,0	-
22	Wheat flour,wholegrain, Sunnuntai	1420	-	13	2,9	17	53	-	-	-	-	-	-	1,4	54	-	-	-	13	-
23	Wheat flour,wholegrain, Mylläri_Luomu	1425	-	13	2,8	12	59	-	-	-	-	-	-	0,80	60	-	-	-	12	-
24	Wheat flour,wholegrain, graham, Myllyn_Paras	1390	0,0050	14	3,0	14	55	-	-	-	-	-	-	0,80	56	-	-	-	13	0,0050
25	Yeast bread_flour, Myllyn_Paras	1420	0,0070	13	2,5	14	63	-	-	-	-	-	-	0,40	63	-	-	-	7,0	0,0070
26	Barley flour,Myllyn_Paras	1410	0,0050	14	2,0	10	63	-	-	-	-	-	-	1,0	64	-	-	-	10	0,0050
27	Barley flour,Kinnusen_Mylly	1345	0,010	14	2,0	8,6	65	-	-	-	-	-	-	0,50	65	-	-	-	11	0,010
28	Rye flour,Kinnusen_Mylly	1280	-	8,6	2,0	8,4	60	-	-	-	-	-	-	1,3	61	-	-	-	20	-
29	Rye flour_sieve, Kinnusen_Mylly	1355	0,010	12	2,0	7,0	66	-	-	-	-	-	-	1,5	67	-	-	-	12	0,010

30	Rye flour,Pirkka	1407	-	9,0	2,0	10	58	-	-	-	-	-	-	1,3	59	-	-	-	20	-
31	Flour, Breadcrumbs, Myllyn_Paras	1570	0,010	7,7	2,0	14	69	-	-	-	-	-	-	3,1	72	-	-	-	4,3	0,010
32	Semolina,Myllyn_Paras	1444	0,010	15	1,4	11	69	-	-	-	-	-	-	0,40	69	-	-	-	4,0	0,010
33	Semolina,Pirkka	1490	-	13	2,0	12	70	-	-	-	-	-	-	0,30	70	-	-	-	3,0	-
34	Wheat flour,Kungsörnen	1450	-	15	1,5	10	-	-	-	-	-	-	-	-	71	-	-	-	3,0	-
35	Wheat flour,Favorit	1423	0,010	15	1,5	10	71	-	-	-	-	-	-	0,50	71	-	-	-	2,9	0,010
36	Wheat flour,graham, Kungsörnen	1400	-	16	2,5	12	60	-	-	-	-	-	-	0,50	60	-	-	-	10	-
37	Wheat flour,wholegrain, Møllerens	1370	-	17	2,5	11	57	-	-	-	-	-	-	2,2	59	-	-	-	11	-
38	Flour mix,wheat_and_rye, Møllerens	1394	-	17	2,2	11	61	-	-	-	-	-	-	1,9	63	-	-	-	7,4	-
39	Flour mix_for_oat_bread, Møllerens	1061	0,70	37	2,4	8,4	44	-	-	-	-	-	-	2,6	46	-	-	-	5,3	0,70
40	Flour mix,oat_bread,Regal	1050	0,80	40	4,3	9,2	40	-	-	-	-	-	-	1,7	42	-	-	-	4,0	0,80
41	Oat flakes_for_porridge, Elovena	1550	-	12	8,0	14	54	-	-	-	-	-	-	1,2	55	-	-	-	11	-

Table 2.3. Major nutrients. Category 1: Flours and flakes; **Values for Generic products from the FCDBs**. Energy unit kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g	g/ 100 g
	Generic products																			
42	Wheat flour,coarse	1541	0,20	10	1,3	11	74	<0,1	-	<0,1	-	1,2	-	1,6	76	1,4	1,3	0,80	3,5	-
43	Wheat flour(2dl),semi-coarse+bakin powder(1ts)	1484	3,8	9,8	1,2	11	71	-	-	-	-	1,1	-	1,5	73	-	-	-	-	2,1
44	Wheat flour,semi-coarse	1560	0,53	10	1,6	12	73	<0,1	-	<0,1	0,20	0,90	-	1,2	74	1,6	1,5	0,80	3,9	-
45	Wheat flour,wholegrain	1498	1,8	6,4	2,5	13	63	<0,1	-	<0,1	0,20	0,90	-	1,2	64	8,0	1,4	1,4	11	0,013
46	Flour, breadcrumbs	1533	0,54	6,0	1,6	12	72	<0,1	-	<0,1	0,20	0,89	-	1,2	74	1,6	1,5	0,80	3,9	0,012
47	Semo-lina	1345	0,40	20	1,1	12	63	0,10	-	0,20	0,10	-	-	0,40	64	1,6	1,5	0,80	3,9	0,0076
48	Barley flour	1370	1,4	14	2,0	8,3	64	0,20	-	0,20	0,50	-	-	0,90	64	5,3	2,9	2,8	11	-
49	Rye flour,wholegrain	1355	1,5	9,1	1,9	9,6	58	0,30	-	0,25	0,86	0,48	-	1,9	59	9,3	3,6	4,6	18	-
50	Rye flour, fine	1428	0,90	14	1,5	10	66	0,20	-	0,10	0,20	-	-	0,50	66	9,3	3,6	4,6	18	0,0089
51	Spelt flour,wholegrain	1461	1,8	11	2,4	13	62	0,20	-	0,17	0,54	0,45	-	1,4	64	7,4	1,9	1,2	11	-
52	Wheat flour,wholegrain	1439	1,9	9,0	2,5	13	60	0,23	-	0,050	0,69	0,55	-	1,5	62	8,0	1,4	1,4	11	-
53	Tapioca flour	1561	0,11	11	<0,1	0,19	88	1,7	-	-	1,7	-	-	3,4	91	0,30	0,30	-	0,50	-
54	Flour mix,rye_and_wheat	1354	1,0	14	1,7	11	65	0,18	-	0,15	0,53	0,69	-	1,5	67	5,5	2,6	2,7	11	-
55	Bun flourmix,wheat_and_rye	1313	0,81	21	1,9	11	59	0,10	-	0,10	0,30	-	-	0,50	59	5,1	2,2	2,2	9,6	-
56	Wheat flour,unfortified	1473	0,52	13	1,9	8,5	69	0,070	-	0,050	0,26	1,2	0,05	1,5	70	2,0	1,1	3,0	3,6	-
57	Wheat flour,wholegrain	1404	1,4	11	2,0	11	46	0,20	-	0,25	0,50	0,20	-	1,2	61	9,7	1,6	2,5	14	-
58	Barley flour,wholegrain	1428	1,5	14	3,0	9,2	64	-	-	-	0,50	-	-	0,90	65	-	-	-	7,6	0,010

59	Rye flour,wholegrain	1359	1,5	11	1,7	8,7	35	0,30	-	0,55	0,90	0,30	-	2,0	59	-	-	-	19	0,010
60	Wheat flour,durum	1471	0,87	11	1,6	12	45	-	-	0,30	0,50	0,90	-	1,7	68	-	-	-	6,3	-
61	Flour mix,wheat,barley, rye_and_oat	1453	0,90	13	2,3	8,7	67	-	-	-	0,44	-	0,03	1,4	69	-	-	-	6,8	-
62	Flour mix,sifted_rye_and_wheat	1452	0,80	14	2,5	9,2	65	-	-	-	0,50	-	-	3,2	68	-	-	-	5,1	0,010
63	Wheat flour,wholegrain	1331	0,57	13	2,4	13	52	-	-	-	-	-	-	-	54	-	-	-	12	0,0051
64	Oats, rolled,oat_flakes	1599	1,9	7,8	7,2	14	59	<0,1	-	<0,1	1,0	<0,1	-	1,2	60	5,9	4,6	0,40	11	-
65	Flour, unspecified	1494	0,22	13	1,5	11	71	-	-	-	-	-	-	-	72	-	-	-	3,4	-
66	Barley flour,50% wholegrain	1278	0,41	15	1,1	8,6	60	-	-	-	-	-	-	-	61	-	-	-	7,6	0,0051
67	Oat flour	1575	0,64	10	7,0	12	60	-	-	-	-	-	-	-	62	-	-	-	8,5	0,025
68	Rye flour,wholegrain	1348	0,48	14	2,4	9,6	56	-	-	-	-	-	-	-	58	-	-	-	15	-
69	Flour mix,wholegrain	1365	0,36	14	2,0	12	59	-	-	-	-	-	-	-	61	-	-	-	7,5	0,0051
70	Oat grains	1444	0,64	11	6,8	11	52	-	-	-	-	-	-	-	52	-	-	-	15	0,025
71	Rice	1516	0,13	11	0,80	6,4	80	-	-	-	-	-	-	-	81	-	-	-	1,1	-
72	Bran flakes	1469	2,4	5,0	2,0	9,0	39	-	-	-	-	-	-	19	66	-	-	-	15	1,8
73	Flour mix,wholegrain, rye,wheat, oat_and_barley	1503	0,53	10	5,5	11	52	-	-	-	-	-	-	-	60	-	-	-	12	0,0051

Table 2.4. Category 2: 'Cereal flakes' (processed). The results from analysis of gluten-free products and values for branded and generic products. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Gluten-free products																			
74	Cereal flakes,gluten_free, Schär	1400	1,2	4,5	0,64	6,3	67	1,3	<0,05	1,1	4,9	<0,05	<0,05	7,3	75	n.a.	n.a.	n.a.	6,0*	0,58
75	Corn flakes,gluten_free, Schär	1446	2,3	5,3	0,20	7,5	73	0,47	<0,05	0,49	1,8	<0,05	<0,05	2,8	76	2,2	1,2	<0,2	3,4	1,8
76	Special_flakes,fortified, gluten_free,Semper	1570	0,83	4,8	0,74	6,2	75	0,54	<0,05	0,60	7,8	<0,05	<0,05	9,0	84	0,2	1,0	<0,2	1,2	0,44
	Branded products																			
77	Special_flakes,Kellogg`s	1578	1,0	5,4	1,5	9,3	66	-	-	-	-	-	-	12	78	-	-	-	4,8	1,0
78	Breakfast_cereals,Fitness	1534	0,72	5,6	1,7	9,3	63	-	-	-	-	-	-	8,8	72	-	-	-	11	0,72
79	All Bran,Kellogg`s	1517	0,68	5,7	2,6	12	51	-	-	-	-	-	-	14	65	-	-	-	14	0,68
80	Corn Flakes,Kellogg's	1604	1,1	6,1	0,90	7,0	76	-	-	-	-	-	-	8,0	84	-	-	-	0,9	1,1
81	Special_flakes,Kellogg`s	1578	1,0	5,4	1,5	9,3	66	-	-	-	-	-	-	12	78	-	-	-	4,8	1,0
82	Special_flakes, fortified,Favorit	1552	1,7	5,0	1,2	13	63	-	-	-	-	-	-	13	76	-	-	-	3,1	1,7
83	Special_flakes, fortified,Eldorado	1600	1,8	5,6	1,5	13	63	-	-	-	-	-	-	13	76	-	-	-	2,1	1,8
	Generic products																			
84	Cereal mix	1668	0,9	5,0	5,8	7,8	52	-	-	-	-	-	-	19	75	-	-	-	5,8	0,48
85	Corn-flakes	1604	1,4	3,0	0,90	7,0	76	-	-	-	-	-	-	6,2	84	-	-	-	3,0	1,3
86	Breakfast_cereal, wholegrain, fortified	1605	1,9	4,3	2,2	9,2	68	0,51	-	0,56	9,6	0,53	-	11	79	-	-	-	3,7	1,1
87	Breakfast_cereal, wholegrain	1605	1,9	4,3	2,2	9,0	68	0,51	-	0,56	9,6	0,53	-	11	79	-	-	-	3,7	1,1
88	Rye cereal	1413	1,7	10	3,8	9,4	53	-	-	-	-	-	-	5,0	60	-	-	-	12	1,2

Table 2.5. Category 3: 'Muesli and granola'. The results from analysis of gluten-free products and values for branded and generic products. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Gluten-free products																			
89	Musli with_fruit,gluten free,Finax	1562	2,0	6,0	4,7	8,1	42	3,5	<0,05	3,6	13	0,13	<0,05	20	62	18	6,5	0,2	25	1,0
90	Musli with_raisins_and_figs, gluten_free,Risenta	1635	2,7	8,6	15	12	28	12	<0,05	12	0,18	<0,05	<0,05	24	52	n.a.	n.a.	n.a.	7,0*	0,45
91	Grano-la_with_blueberries, rhubarb_etc.,Paulún's, Orkla_Foods	1592	2,1	6,0	20	11	31	1,5	<0,05	4,7	1,6	<0,05	<0,05	7,8	39	n.a.	n.a.	n.a.	16	0,37
	Branded products																			
92	Musli with_fruit,Axa_F-musli	1464	0,20	14	6,00	8,8	48	-	-	-	-	-	-	13	61	-	-	-	10	0,20
93	Musli with_fruit,Budget	1514	0,10	12	6,5	11	52	-	-	-	-	-	-	8,0	60	-	-	-	10	0,10
94	Musli with_fruit, Salt_å_Kvarn	1400	0,20	16	2,7	8,3	46	-	-	-	-	-	-	16	62	-	-	-	11	0,20
95	Musli with_fruit_and_berries, Frebaco	1450	0,20	12	2,7	11	58	-	-	-	-	-	-	8,2	66	-	-	-	8,5	0,20
96	Grano-la_with_cardamom, blueberries_etc., Risenta	1800	0,42	3,6	17	10	42	-	-	-	-	-	-	4,0	46	-	-	-	23	0,42
97	Grano-la_with_blueberries, dates_and_cardamom,Axa	1750	0,30	7,9	18	8,8	36	-	-	-	-	-	-	12	48	-	-	-	17	0,30
	Generic products																			
98	Musli with_fruit	1583	1,5	7,5	6,1	9,4	53	4,0	-	6,3	2,1	0,40	0,10	13	66	-	-	-	9,3	0,20
99	Musli with_fruit_and_berries	1547	1,6	11	6,6	8,2	47	4,6	-	5,0	5,2	0,27	-	15	63	-	-	-	7,7	0,30

Table 2.6. Category 4: 'Breads and wraps'. **Results from the analysis of gluten-free products**. The energy unit is kJ, all the other nutrients are expressed as g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Gluten-free products																			
100	Crisp bread,gluten_free, Pirkka	1648	3,1	6,9	6,0	8,2	71	0,34	<0,05	0,58	<0,05	0,11	<0,05	1,0	72	3,8	4,6	0,2	8,6	1,9
101	Millet-corn_cake, Bio_Zentrale	1596	1,1	4,8	2,7	8,9	77	0,060	<0,05	0,060	0,26	<0,05	<0,05	0,4	78	n.a.	n.a.	n.a.	3,3*	0,010
102	Kare-lian_pasty_with rice_filling, Vuohelan_herkku	831	1,6	53	5,2	3,8	33	0,14	<0,05	<0,05	<0,05	0,090	<0,05	0,2	33	n.a.	n.a.	n.a.	2,0*	0,98
103	Buck-wheat_bread, gluten_free	965	2,0	41	2,2	6,1	44	0,60	<0,05	0,18	<0,05	<0,05	<0,05	0,8	44	n.a.	n.a.	n.a.	3,3*	1,1
104	Crac-kers,gluten_free, Schär_Salti	1866	2,3	2,2	13	2,6	70	2,1	<0,05	0,18	5,0	<0,05	<0,05	7,3	77	n.a.	n.a.	n.a.	4,4*	1,7
105	Cia-batta,gluten_free, Schär	1179	1,8	31	7,2	6,0	39	1,8	<0,05	1,7	0,11	2,4	<0,05	6,0	45	n.a.	n.a.	n.a.	6,8*	0,82
106	Wraps, gluten_free,Schär	1286	1,5	32	6,1	7,3	39	3,7	0,070	0,20	<0,05	1,5	<0,05	5,4	45	4,0	6,7	2,2	13	0,79
107	Wraps, gluten_free,Bfree	1642	2,2	3,4	1,3	5,4	65	<0,05	<0,05	<0,05	15	<0,05	2,7	18	83	n.a.	n.a.	n.a.	11*	1,4
108	Dark loaf_with_linseed, gluten_free, Fria_Bröd	1055	1,7	33	2,5	0,9	46	2,6	<0,05	3,1	<0,05	1,1	<0,05	6,8	53	2,3	3,5	<0,2	5,8	1,2
109	Crisp bread_with_chia, gluten_free,Semper	1483	2,2	5,9	2,3	4,7	72	0,25	<0,05	0,16	<0,05	<0,05	<0,05	0,4	73	6,7	3,5	<0,2	10	1,3
110	Sour-dough_bread, gluten_free,Dr_Schär	894	1,5	44	3,2	3,4	32	2,6	<0,05	2,1	<0,05	0,95	<0,05	5,7	38	5,2	3,3	1,2	9,7	0,95
111	Sour-dough_bread, gluten_free, Friends_of_Adam	715	1,8	57	1,8	3,6	32	0,025	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	32	n.a.	n.a.	n.a.	5,0*	1,1
112	Crisp bread_with_sesame and_seasalt, gluten_free,Wasa	1768	2,2	5,7	11	6,1	67	0,71	0,37	0,56	<0,05	<0,05	<0,05	1,6	69	7,4	2,2	<0,2	9,6	1,2

Table 2.7. Category 4: 'Breads and wraps'. **Branded products**. The nutrition information comes from the packages. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Branded products																			
113	Rye crispbread, Koulunäkki,Vaasan	1450	1,0	8,1	2,9	9,0	59	-	-	-	-	-	-	2,7	62	-	-	-	17	1,0
114	Rye crispbread, Finn_Crisp, Oululainen	1550	1,4	0,80	2,8	12	59	-	-	-	-	-	-	1,4	60	-	-	-	23	1,4
115	Water biscuit(Cream Cracker),Kantolan	1900	1,1	4,6	17	10	63	-	-	-	-	-	-	2,0	65	-	-	-	2,3	1,1
116	Kare- lian_Pasty,Fazer	941	1,0	51	7,3	4,1	30	-	-	-	-	-	-	4,5	34	-	-	-	2,9	1,0
117	Rye bread,Vaasan	1047	1,1	32	1,7	10	42	-	-	-	-	-	-	1,1	43	-	-	-	12	1,1
118	Salty biscuits,Sætre Snackers_salt	2250	1,3	1,4	31	5,3	54	-	-	-	-	-	-	5,8	60	-	-	-	1,0	1,3
119	Crac- kers,Ritz	2045	1,5	3,5	23	7,8	53	-	-	-	-	-	-	8,4	61	-	-	-	3,3	1,5
120	Crac- kers,salt,Tuc	2006	1,8	1,6	19	8,3	60	-	-	-	-	-	-	7,1	67	-	-	-	2,4	1,8
121	Cia- batta,coarse, Rema_1000	1049	1,1	37	2,0	8,3	42	-	-	-	-	-	-	3,2	45	-	-	-	6,6	1,1
122	Cia- batta,Rema_1000	1145	1,2	33	2,0	9,1	50	-	-	-	-	-	-	2,0	52	-	-	-	2,7	1,2
123	Cia- batta,baked_in stone_oven, Eldorado	1054	1,3	37	1,5	8,9	46	-	-	-	-	-	-	2,4	48	-	-	-	3,0	1,3
124	Tortil- las,Old_El_Paso	1264	1,0	32	5,2	9,1	51	-	-	-	-	-	-	2,1	53	-	-	-	-	1,0
125	Tortil- las,Original, Santa_Maria	1252	1,6	30	5,2	7,6	52	-	-	-	-	-	-	1,7	54	-	-	-	2,4	1,6
126	Tortil- las,Rema_1000	1379	1,0	23	7,0	9,3	56	-	-	-	-	-	-	0,90	57	-	-	-	3,0	1,0
127	Tortil- las,wholegrain, Old_El_Paso	1207	1,0	34	6,0	8,3	44	-	-	-	-	-	-	3,0	47	-	-	-	3,7	1,0

128	Tortil-las,whole_wheat, medium,Santa_Maria	1171	1,2	33	5,5	8,0	45	-	-	-	-	-	-	2,4	47	-	-	-	5,2	1,2
129	Tortil-las,wholegrain, Rema_1000	1238	0,84	30	5,9	9,8	45	-	-	-	-	-	-	1,6	47	-	-	-	6,8	0,84
130	Toast bread,Fiberrost, Skogaholm	1100	0,80	35	3,6	10	42	-	-	-	-	-	-	2,6	45	-	-	-	5,2	0,80
131	Toast bread,Rasker,Pågen	1100	1,0	36	4,0	10	39	-	-	-	-	-	-	4,8	44	-	-	-	5,0	1,0
132	Crisp bread_with_chia_and seasalt,Wasa	1454	1,3	6,4	3,6	11	57	-	-	-	-	-	-	0,20	57	-	-	-	21	1,3
133	Sour-dough_bread, Kärnsund, Pågen	1013	1,0	40	3,3	9,9	37	-	-	-	-	-	-	3,4	40	-	-	-	6,2	1,0
134	Sour-dough_bread, Lantgoda, Pågen	1096	0,92	35	3,0	11	41	-	-	-	-	-	-	4,1	45	-	-	-	5,0	0,92
135	Sour-dough_bread,organic, Fazer	1299	1,1	33	6,7	9,0	40	-	-	-	-	-	-	4,3	44	-	-	-	6,2	1,1
136	Sour-dough_bread,Rustik levain,Skogaholm	950	1,2	42	1,4	7,5	44	-	-	-	-	-	-	1,0	45	-	-	-	2,7	1,2
137	Sour-dough_bread,Bondens surdegsbröd,Fazer	850	1,2	46	1,7	5,5	36	-	-	-	-	-	-	1,0	37	-	-	-	8,8	1,2
138	Crisp bread_with_sesame and_seasalt,Wasa	1700	1,4	6,6	10	12	61	-	-	-	-	-	-	3,5	64	-	-	-	6,0	1,4

Table 2.8. Category 4: 'Breads and wraps'. **Values for generic products from the FCDBs**. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g
	Generic products																			
139	Crisp bread,rye, 17%fibre	1507	2,8	19	2,3	11	62	0,41	-	0,28	0,96	0,54	-	2,2	64	11	4,1	5,2	21	1,0
140	Water biscuit,Cream Cracker	1780	1,9	18	11	10	62	0,089	-	0,18	5,7	-	-	6,0	68	1,4	1,3	0,7	3,6	1,4
141	Water biscuit_with_rye flour,Cream_Cracker, Kantolan	1661	1,7	13	13	9,4	56	0,13	-	0,18	1,3	0,12	-	1,7	58	3,2	1,8	1,6	6,7	0,58
142	Kare- lian_pasty,rice_filling, Imatran,Fazer	940	1,5	50	7,3	4,1	30	2,3	-	<0,1	1,9	0,13	<0,1	4,5	34	1,6	0,8	0,7	3,2	1,0
143	Rye Bread,Vaasan	1076	2,3	32	1,4	9,5	45	0,29	-	0,27	0,38	0,12	-	1,0	46	4,9	2,3	2,2	10	1,1
144	Salty biscuits	1952	2,4	3,0	23	8,6	46	-	-	-	-	-	-	5,6	54	-	-	-	3,8	2,1
145	Cia- batta	1131	0,62	39	5,4	7,6	45	-	-	-	-	-	-	-	46	-	-	-	2,5	0,46
146	Tortilla,wheat	1251	1,7	28	3,1	9,0	56	-	-	-	-	-	-	-	57	-	-	-	2,7	1,5
147	Tortilla,wholegrain_wheat	1075	1,1	37	5,3	8,2	38	-	-	-	-	-	-	0,80	40	-	-	-	6,9	0,8
148	White bread,fiber-rich	1088	1,7	36	4,2	8,6	36	0,46	-	0,87	0,050	2,5	-	3,9	40	-	-	-	5,4	1,0
149	Crisp bread,wholemeal, 20%fibre	1472	2,7	7,1	3,3	8,6	59	0,12	-	0,48	0,20	0,36	-	1,2	60	-	-	-	14	1,2
150	Sour- dough_bread	1043	1,9	37	1,5	7,5	47	0,10	-	0,060	-	1,6	-	1,8	49	-	-	-	2,5	1,3
151	Wheat and_rye_bread, 7%fibre	974	1,5	42	2,8	6,8	34	1,9	-	3,0	-	0,86	-	5,8	42	-	-	-	5,4	0,79
152	White bread,5%fibre	1034	1,3	40	4,2	7,4	38	-	-	0,27	-	2,0	-	2,3	42	-	-	-	5,1	1,0
153	Bagu- ette,2.5%fibre	1131	1,7	32	1,7	8,5	49	0,13	-	0,36	-	3,1	-	3,6	53	-	-	-	2,6	1,0
154	Wheat	1036	1,3	37	2,2	7,4	32	3,4	-	4,4	-	2,4	-	10	46	-	-	-	5,6	0,69

	and_rye_bread, wholemeal, 6%fibre																		
155	White bread,loaf, 5%fibre	1030	1,4	37	2,0	6,8	33	3,9	-	4,8	-	1,8	-	10	47	-	-	-	6,0	0,81
156	Rye bread,wholemeal, 7%fibre	947	1,7	42	2,3	9,3	26	0,94	-	1,2	-	2,7	-	4,9	38	-	-	-	6,5	0,88
157	Crisp bread,wholemeal, rye_sesame_seed wheat_bran_wheat_sprouts, 24%fibre	1486	3,8	5,7	8,2	13	34	0,10	-	0,10	1,9	0,30	-	2,4	36	-	-	-	24	1,5
158	Crisp bread,wholemeal, rye,15%fibre	1458	2,4	6,4	1,7	8,8	56	0,030	-	0,62	0,12	0,47	-	1,2	67	-	-	-	14	1,1
159	Bread, wholegrain75–100%A	927	0,70	40	1,5	8,7	37	-	-	-	-	-	-	-	39	-	-	-	8,1	0,30
160	Bread, wholegrain_spelt	956	1,3	40	1,3	8,2	41	-	-	-	-	-	-	0,80	43	-	-	-	6,0	1,0
161	Bread, wholegrain50–75%	1022	1,4	36	3,4	8,8	40	-	-	-	-	-	-	0,1	41	-	-	-	5,4	1,1
162	Bread, wholegrain75–100%B	954	1,4	37	3,3	11	33	-	-	-	-	-	-	1,0	35	-	-	-	6,6	1,0
163	Oat bread	977	1,4	36	4,0	8,0	36	-	-	-	-	-	-	1,0	38	-	-	-	5,0	1,1

Table 2.9. 'Waffle mix and cookies'. The results from the analysis of gluten-free products and values for branded and generic products. The energy unit is kJ, other nutrients are shown in g/100g in fresh weights.

PCA ID	Product name	Energy	Ash	Moisture	Fat	Protein	Starch	Glc	Gal	Fru	Suc	Mal	Lac	Total sugars	Carb	IDF	SDFP	SDFS	Total DF	Salt
		kJ	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100 g	g/100
	Gluten-free products																			
164	Waffel mix,gluten_free, TORO	883	2,2	38	2,4	6,0	38	0,99	<0,05	0,28	<0,05	1,5	<0,05	2,7	41	n.a.	n.a.	n.a.	n.a.	1,2
165	Choco Chips_Cookies, gluten_free,Schär	2040	1,1	4,1	28	4,5	38	0,11	<0,05	<0,05	16,8	0,26	<0,05	17	55	n.a.	n.a.	n.a.	n.a.	0,51
	Branded products																			
166	Waffel mix,TORO	1277	0,91	53	1,2	6,5	29	-	-	-	-	-	-	9,3	38	-	-	-	1,4	0,91
167	Pan-cakes_ready-made,Pancake_flour, Myllyn_Paras	633	0,59	63	1,2	7,0	24	-	-	-	-	-	-	3,3	27	-	-	-	1,7	0,59
168	Pan-cake_flour (Myllyn_Paras)+10% butter_for_frying	874	0,68	58	9,2	6,4	21	-	-	-	-	-	0,08	3,0	24	-	-	-	1,5	0,68
169	Coo-kies_Choc_Chip, Rema_1000	2214	0,58	8,5	24	5,8	32	-	-	-	-	-	-	29	61	-	-	-	0,70	0,58
170	Sætre Safari_Original chocolate_cookie	2100	0,70	16	13	5,5	30	-	-	-	-	-	-	33	63	-	-	-	2,9	0,70
171	Sætre CafèBakeriet Sjokladeterapi chocolate_cookie	2100	0,70	19	11	6,0	23	-	-	-	-	-	-	38	61	-	-	-	2,9	0,70
	Generic products																			
172	Waff-les	1214	1,3	43	14	8,2	21	-	-	-	-	-	-	8,9	32	-	-	-	1,0	1,0
173	Coo-kies	2056	1,1	3,0	25	5,7	28	-	-	-	-	-	-	29	59	-	-	-	2,3	0,80

Appendix 3. Values for essential and non-essential elements, in fresh weights

The chemical element contents used in this study are presented in Tables 3.1–3.7 according to the product categories:

Tables 3.1 and 3.2:	Category 1, 'Flours and flakes' (divided in two tables for better readability)
Table 3.3:	Category 2, 'Cereal flakes'
Table 3.4:	Category 3, 'Muesli and granola'
Tables 3.5 and 3.6:	Category 4, 'Breads and wraps' (divided in two tables for better readability)

Each category contains **gluten-free** and **generic products**. Gluten-free products were analysed in laboratories during this project. The nutritional information of generic products was collected from the Food Composition Databases (FCDBs). Branded products did not contain information about the chemical elements.

The sodium content may be calculated from the salt results given in Appendix 2 by using the factor 2,548 (Na (mg/100g) = salt (g/100g)*1000/2,548).

- = value is missing /

LOD values for chemical elements analysed in gluten-free products are presented in Table 7 in the report.

Table 3.1. Chemical elements. Category 1: 'Flours and flakes'. **The results from the analysis of gluten-free products**. The results are expressed as mg/100g or mg/100g in fresh weights.

Flours and flakes		*Essential elements*														*Non-essential elements*					
PCA ID	**Product name**	**Ca** mg/100 g	**Co** µg/100 g	**Cr** µg/100 g	**Cu** mg/100 g	**Fe** mg/100 g	**I** µg/100 g	**K** mg/100 g	**Mg** mg/100 g	**Mn** µg/100 g	**Mo** µg/100 g	**Na** mg/100 g	**P** mg/100 g	**Se** µg/100 g	**Zn** mg/100 g	**As** µg/100 g	**Ag** µg/100 g	**Al** µg/100 g	**Cd** µg/100 g	**Hg** µg/100 g	**Ni** µg/100 g	**Pb** µg/100 g
	Gluten-free products																					
1	Bun flour_mix, gluten_free, Viljatuote	13	0,53	2,9	0,16	0,62	<8	160	45	890	25	5,5	130	<5	0,93	16	0,24	390	0,25	0,19	7,3	0,58
2	Baking flour_with_oats, gluten_free, Provena	17	0,66	1,6	0,088	0,58	<8	140	20	470	17	240	70	<5	0,50	3,0	0,08	260	0,87	0,11	22	0,31
3	Corn flour,Risenta	2,5	0,29	2,8	0,11	1,5	<8	180	53	250	13	0,36	140	<5	1,0	0,42	0,06	300	0,14	0,07	12	0,26
4	Buck-wheat_flour, Keskisen_Mylly	81	1,2	15	0,076	6,6	<8	160	26	620	7,0	390	64	<5	0,43	2,2	0,11	2000	2,9	0,11	15	2,1
5	Oat flour,_wholegrain, gluten_free, Viljatuote	43	1,6	<0,4	0,38	4,5	<8	34	110	3300	110	1,1	370	11,6	2,6	0,54	0,09	16	1,6	0,10	200	0,05
6	Buck-wheat_flour, coarse,Viljatuote	22	9,5	0,75	0,71	3,9	<8	640	290	2400	65	0,34	630	<5	5,2	0,63	4,1	410	8,3	0,14	210	0,36
7	Rice flour,Viljatuote	6,0	0,34	<0,4	0,14	0,18	<8	82	27	840	34	4,8	98	<5	1,0	18	0,30	27	2,7	0,31	7,3	0,03
8	Teff flour,Oriola	150	4,3	17	0,65	7,1	<8	330	160	9800	10	2,1	350	<5	2,8	0,90	0,62	4000	0,44	0,10	310	1,9
9	Sugar beet_flakes,Fibrex	732	16	296	0,39	41	<8	120	174	5400	10	110	46	<5	1,7	14	0,76	58	18	0,28	150	93
10	Maize groats,Risenta	2,1	0,30	1,0	0,095	1,1	<8	190	59	260	18	0,28	160	<5	1,1	0,49	0,03	51	0,14	<0,04	13	0,09
11	Buck-wheat_flour, Risenta	13	6,5	2,8	0,42	2,2	<8	370	180	1400	39	0,27	340	<5	1,8	0,37	0,91	380	3,4	0,11	140	0,28
12	Flour mix,coarse, gluten_free,TORO	50	3,2	43	0,18	3,9	<8	140	57	640	15	410	110	<5	0,76	2,3	0,13	4000	1,6	0,07	38	5,9
13	Oat bread_mix, gluten_free,TORO	130	2,7	37	0,12	3,2	<8	110	37	860	12	630	200	<5	0,58	1,8	0,08	3800	1,4	0,10	30	5,0
14	Flour	7,9	0,32	3,4	0,051	6,1	<8	44	12	180	12	48	56	<5	0,41	3,6	0,12	350	0,10	0,11	3,6	0,33

	mix,Finmix, Semper																					
15	Flour mix,Finax	110	0,64	6,4	0,012	5,1	8,9	140	13	53	13	37	120	<5	0,41	0,09	0,02	200	0,05	0,08	2,4	0,16
16	Rice flakes, Myllyn_Paras	5,4	0,32	<0,4	0,12	0,14	<8	70	24	860	62	0,65	88	<5	0,84	17	0,07	17	3,7	0,41	9,2	0,08

Table 3.2. Chemical elements. Category 1: 'Flours and flakes'. **Values for generic products from the FCDBs**. The results are expressed as mg/100g or mg/100g in fresh weights.

Flours and flakes		*Essential elements*															*Non-essential elements*						
PCA ID	**Product name**	**Ca** mg/100g	**Co** µg/100g	**Cr** µg/100g	**Cu** mg/100g	**Fe** mg/100g	**I** µg/100g	**K** mg/100g	**Mg** mg/100g	**Mn** µg/100g	**Mo** µg/100g	**Na** mg/100g	**P** mg/100g	**Se** µg/100g	**Zn** mg/100g	**As** µg/100g	**Ag** µg/100g	**Al** µg/100g	**Cd** µg/100g	**Hg** µg/100g	**Ni** µg/100g	**Pb** µg/100g
										Generic products												
42	Wheat flour,coarse	19	-	1,0	0,14	0,50	10	130	22	400	10	1,0	95	9,9	0,70	-	-	-	-	-	-	-
43	Wheat flour(2dl),semi-coarse+baking powder(1ts)	820	-	-	0,13	0,47	9,3	130	21	-	-	840	690	9,2	0,85	-	-	-	-	-	-	-
44	Wheat flour,semi-coarse	19	2,0	1,0	0,17	0,90	10	160	29	590	10	1,0	120	10	0,80	3,0	-	700	3,0	0,20	-	-
45	Wheat flour,wholegrain	34	2,0	1,0	0,55	3,5	10	430	140	3000	10	5,0	510	7,0	4,2	3,0	-	700	3,0	0,20	-	-
46	Flour, breadcrumb	19	2,0	0,99	0,17	0,90	10	150	29	590	9,9	4,9	120	10	0,80	3,0	-	700	3,0	0,20	-	-
47	Semo-lina	13	2,0	1,0	0,20	1,2	5,0	150	21	500	10	3,0	95	7,7	0,80	3,0	-	700	3,0	0,20	-	-
48	Barley flour	23	1,0	2,0	0,56	4,5	5,0	360	89	1600	10	1,0	300	8,6	2,8	3,0	-	1000	2,0	0,20	-	-
49	Rye flour,wholegrain	33	3,0	2,0	0,39	3,3	5,0	450	97	2000	10	1,0	310	5,0	2,9	3,0	-	1300	0,77	0,20	-	-
50	Rye flour,fine	22	2,0	2,0	0,42	2,2	10	290	56	2100	10	3,5	190	1,0	1,9	2,5	-	900	0,80	0,20	-	-
51	Spelt flour,wholegrain	27	-	21	0,60	4,9	-	400	140	2900	-	1,0	450	1,7	4,8	-	-	-	-	-	-	-
52	Wheat flour,wholegrain	32	2,0	2,0	0,49	3,9	5,0	420	120	3100	20	1,0	350	7,6	3,0	3,0	-	840	5,0	0,20	-	-
53	Tapio-ca_flour	20	-	-	0,02	1,6	-	11	1,0	110	-	1,0	7,0	0,80	0,12	-	-	-	-	-	-	-
54	Flour mix,rye_an wheat	26	2,5	1,5	0,28	2,1	7,5	300	63	1300	10	1,0	210	7,5	1,9	3,0	-	990	1,9	0,20	-	-
55	Bun flour_mix, wheat_and_rye	17	1,0	2,0	0,30	2,4	5,0	240	51	1400	12	1,0	180	9,5	1,6	3,0	-	700	3,2	0,20	-	-
56	Wheat flour,unfortified	21	0,58	0,70	0,15	0,70	2,0	170	21	380	20	0,8	110	10	0,56	-	-	-	4,5	-	1,8	0,60
57	Wheat	29	-	-	0,37	3,0	-	360	98	2000	42	1,3	290	2,6	2,3	-	-	-	4,0	-	13	-

	flour,wholegrain																				
58	Barley flour,wholegrain	27	-	2,0	0,56	3,5	0,50	350	89	1600	20	2,0	250	1,0	2,4	-	-	-	-	-	-	-
59	Rye flour,wholegrain	32	-	-	0,32	2,6	-	430	87	2100	72	2,5	290	3,2	2,8	-	-	-	1,0	-	12	-
60	Wheat flour,durum	23	-	5,5	0,33	2,60	-	210	54	1200	64	1,6	170	7,2	1,8	-	-	-	2,0	-	21	-
61	Flour mix,wheat,barley, rye_and_oat	25	-	0,80	0,26	1,6	1,7	250	47	1000	33	1,3	180	7,0	1,3	-	-	-	-	-	-	-
62	Flour mix,sifted rye_and_wheat	29	-	-	-	1,0	-	260	50	-	-	3,0	210	1,0	1,8	-	-	-	-	-	-	-
63	Wheat flour,wholegrain	31	-	-	0,35	4,1	2,3	410	120	-	-	2,0	370	10	2,7	-	-	-	-	-	-	-
64	Oats, rolled,oat_flakes	47	8,0	1,0	0,45	4,7	20	410	140	4,1	20	1,0	470	12	3,6	3,0	-	340	4,4	0,60	-	-
65	Flour, unspecified	18	-	-	0,14	1,3	2,0	170	34	-	-	1,0	130	5,0	0,90	-	-	-	-	-	-	-
66	Barley flour,50% wholegrain	28	-	-	0,56	2,2	0,25	320	60	-	-	2,0	250	3,0	1,5	-	-	-	-	-	-	-
67	Oat flour	53	-	-	0,40	5,0	0,50	430	130	-	-	10	430	1,0	3,1	-	-	-	-	-	-	-
68	Rye flour,wholegrain	24	-	-	0,27	2,8	3,7	370	79	-	-	1,0	330	6,0	2,2	-	-	-	-	-	-	-
69	Flour mix,wholegrain	22	-	-	0,21	2,2	2,3	270	62	-	-	2,0	230	7,0	1,6	-	-	-	-	-	-	-
70	Oat grains	53	-	-	0,40	5,0	0,50	430	130	-	-	10	510	1,0	3,1	-	-	-	-	-	-	-
71	Rice	-	-	-	0,16	0,20	2,1	100	28	-	-	1,0	100	-	1,1	-	-	-	-	-	-	-
72	Bran flakes	28	-	-	0,35	3,3	2,0	450	110	-	-	700	450	2,0	2,0	-	-	-	-	-	-	-
73	Flour mix,wholegrain, rye,wheat,oat and_barley	36	-	-	0,38	3,6	1,1	380	110	-	-	2,0	440	3,0	2,4	-	-	-	-	-	-	-

Table 3.3. Chemical elements. Category 2: 'Cereal flakes'. **The results from the analysis of gluten-free products** and **values for generic products from FCDBs**. The results are expressed as mg/100g or mg/100g in fresh weights.

Cereal flakes		*Essential elements*														*Non-essential elements*							
PCA ID	**English name**	**Ca** mg/100 g	**Co** µg/100 g	**Cr** µg/100 g	**Cu** mg/100 g	**Fe** mg/100 g	**I** µg/100 g	**K** mg/100 g	**Mg** mg/100 g	**Mn** µg/100 g	**Mo** µg/100 g	**Na** mg/100 g	**P** mg/100 g	**Se** µg/100 g	**Zn** mg/100 g	**As** µg/100 g	**Ag** µg/100 g	**Al** µg/100 g	**Cd** µg/100 g	**Hg** µg/100 g	**Ni** µg/100 g	**Pb** µg/100 g
	Gluten-free products																					
74	Cereal flakes,gluten_free, Schär	31	0,72	4,6	0,23	3,6	<8	120	32	700	54	230	120	<5	1,3	14	0,11	46	3,3	0,36	30	1,0
75	Corn flakes,gluten_free, Schär	3,4	0,62	2,2	0,045	0,16	<8	83	8,9	36	18	710	41	<5	0,24	0,34	0,02	17	0,16	0,12	5,0	0,08
76	Special_flakes,fortified, gluten_free,Semper	7,9	1,0	12	0,18	12	<8	88	32	980	51	170	120	<5	1,4	13	0,11	46	6,6	0,29	19	1,7
	Generic products																					
84	Cereal mix	50	-	-	0,27	2,2	1,9	280	60	-	-	190	220	3,0	1,3	-	-	-	-	-	-	-
85	Corn-flakes	5,0	-	-	0,070	2,2	2,0	100	10	-	-	500	50	3,0	0,20	-	-	-	-	-	-	-
86	Breakfast_cereal, wholegrain, fortified	21	0,87	9,4	0,25	7,0	1,8	180	50	1300	36	450	140	-	1,5	1,2	0,20	86	1,7	0,84	23	1,6
87	Breakfast_cereal, wholegrain		0,87	9,4	0,25	3,3	1,8	180	50	1300	36	450	140	-	1,5	-	-	-	1,7	-	23	1,6
88	Rye cereal	27	-	-	0,28	2,8	2,4	350	85	-	-	470	360	4,0	2,1	-	-	-	-	-	-	-

Table 3.4. Chemical elements. Category 3: 'Muesli and granola'. **The results from the analysis of gluten-free products** and **values for generic products from FCDBs**. The results are expressed as mg/100g or mg/100g in fresh weights.

Müsli and granola		*Essential elements*														*Non-essential elements*							
PCA ID	**English name**	**Ca** mg/100 g	**Co** µg/100 g	**Cr** µg/100 g	**Cu** mg/100 g	**Fe** mg/100 g	**I** µg/100 g	**K** mg/100 g	**Mg** mg/100 g	**Mn** µg/100 g	**Mo** µg/100 g	**Na** mg/100 g	**P** mg/100 g	**Se** µg/100 g	**Zn** mg/100 g	**As** µg/100 g	**Ag** µg/100 g	**Al** µg/100 g	**Cd** µg/100 g	**Hg** µg/100 g	**Ni** µg/100 g	**Pb** µg/100 g
	Gluten-free products																					
89	Musli with_fruit, gluten_free,Finax	53	2,7	67	0,17	1,9	<8	180	61	590	22	400	120	<5	0,76	2,4	0,35	1100	1,4	0,07	69	2,7
90	Musli with_raisins_and figs,gluten_free, Risenta	49	6,8	8,5	0,68	3,1	<8	500	200	2300	12	180	460	<5	3,9	1,9	0,14	1000	5,9	0,11	250	0,70
91	Grano-la_with_blueberries, rhubarb_etc., Paulún's,Orkla_Foods	84	3,8	2,1	0,68	3,2	<8	390	150	1900	130	150	380	<5	2,9	2,1	0,03	390	17	0,09	350	0,84
	Generic products																					
98	Musli with_fruit	27	0,90	1,6	0,32	2,5	-	440	81	2000	-	81	250	2,1	1,9	0,90	0,30	370	3,0	0,10	34	1,0
99	Musli with_fruit_and berries	40	0,95	18	0,31	2,3	4,3	420	86	2300	55	120	260	-	1,8	0,90	0,30	370	2,0	0,10	33	-

Table 3.5. Chemical elements. Category 4: 'Breads and wraps'. **The results from the analysis of gluten-free products**. The results are expressed as mg/100g or mg/100g in fresh weights.

Breads and wraps		*Essential elements*														*Non-essential elements*					
PCA ID	**English name**	**Ca** mg/100 g	**Co** µg/100 g	**Cr** µg/100 g	**Cu** mg/100 g	**Fe** mg/100 g	**I** µg/100 g	**K** mg/100 g	**Mg** mg/100 g	**Mn** µg/100 g	**Mo** µg/100 g	**Na** mg/100 g	**P** mg/100 g	**Se** µg/100 g	**Zn** mg/100 g	**As** µg/100 g	**Ag** µg/100 g	**Al** µg/100 g	**Cd** µg/100 g	**Hg** µg/100 g	**Ni** µg/100 g	**Pb** µg/100 g
											Gluten-free products											
100	Crisp bread,gluten_free, Pirkka	57	2,6	14	0,21	2,1	<8	264	49	950	63	770	140	<5	1,3	6,8	0,15	1900	4,8	0,17	86	1,8
101	Millet-corn_cake, Bio_Zentrale	10	3,4	12	0,27	1,6	<8	207	100	1400	53	4	230	5,6	1,6	9,0	0,18	700	3,8	0,29	88	0,79
102	Kare-lian_pasty with_rice_filling, Vuohelan_herkku	11	1,1	5,0	0,099	0,67	25	134	55	1100	17	390	130	<5	0,82	9,7	0,22	240	0,86	0,14	22	1,6
103	Buck-wheat_bread, gluten_free	16	3,0	17	0,18	1,4	<8	226	74	616	26	420	160	<5	1,1	2,6	0,30	790	1,3	0,07	40	1,4
104	Crac-kers,gluten_free, Schär_Salti	16	0,46	2,3	0,053	0,40	<8	116	18	91	14	680	60	<5	0,25	0,53	<0,01	100	0,17	<0,04	5,4	0,10
105	Cia-batta,gluten_free, Schär	22	2,7	15	0,21	1,3	<8	238	48	510	20	320	110	<5	1,0	4,8	0,11	820	3,7	0,10	62	0,71
106	Wraps, gluten_free,Schär	15	0,93	14	0,16	0,95	<8	151	21	465	31	310	88	<5	0,78	6,1	0,10	560	2,6	0,25	31	0,63
107	Wraps, gluten_free,Bfree	84	0,43	7,0	0,15	1,7	<8	168	42	45	19	560	190	5,5	0,82	0,69	0,13	120	1,1	0,05	6,3	0,27
108	Dark loaf_with_linseed, gluten_free,Fria_Bröd	42	3,6	32	0,034	1,7	<8	169	12	186	4,2	470	45	<5	0,21	0,98	0,02	1500	0,52	0,10	29	2,6
109	Crisp bread_with_chia, gluten_free,Semper	79	4,0	20	0,20	2,7	<8	173	54	1060	16	530	120	<5	0,99	4,1	0,23	2700	2,7	0,15	37	3,1
110	Sour-dough_bread, gluten_free,Dr_Schär	24	2,8	17	0,12	1,7	<8	141	36	506	15	370	71	<5	0,60	2,6	0,06	1400	1,7	0,10	22	2,1
111	Sour-dough_bread, gluten_free, Friends_of_Adam	24	4,2	4,1	0,14	1,5	<8	134	34	2110	18	440	96	<5	0,79	3,3	0,17	1300	0,87	0,14	35	3,8
112	Crisp bread_with_sesame and_seasalt, gluten_free,Wasa	150	4,5	5,8	0,22	1,5	<8	175	56	501	27	450	180	5,3	1,2	2,5	0,08	4800	0,81	0,13	14	0,75

Table 3.6. Chemical elements. Category 4: 'Breads and wraps'. **Values for generic products from FCDBs**. The results are expressed as mg/100g or mg/100g in fresh weights.

Breads and wraps		*Essential elements*															*Non-essential elements*				
PCA ID	**English name**	**Ca** mg/100 g	**Co** µg/100 g	**Cr** µg/100 g	**Cu** mg/100 g	**Fe** mg/100 g	**I** µg/100 g	**K** mg/100 g	**Mg** mg/100 g	**Mn** µg/100 g	**Mo** µg/100 g	**Na** mg/100 g	**P** mg/100 g	**Se** µg/100 g	**Zn** mg/100 g	**As** µg/100 g	**Ag** µg/100 g	**Al** µg/100 g	**Cd** µg/100 g	**Hg** µg/100 g	**Ni** µg/100 g	**Pb** µg/100 g
										Generic products												
139	Crisp bread,rye,17%fibre	41	3,8	2,3	0,44	4,1	5,7	530	120	2600	11	410	380	5,6	3,6	3,4	-	1400	0,88	0,23	-	-
140	Water biscuit,Cream Cracker	15	2,3	0,96	0,16	1,1	9,3	140	21	530	9,6	550	90	7,0	0,77	2,9	-	650	2,7	0,19	-	-
141	Water biscuit_with_rye flour,Cream Cracker,Kantolan	16	2,4	1,2	0,20	1,6	33	390	48	850	8,8	230	140	5,9	1,2	2,6	-	760	2,0	0,17	50	-
142	Kare-lian_pasty,rice_filling, Imatran,Fazer	20	0,85	1,	0,13	0,83	28	120	24	540	7,4	410	79	5,2	0,78	2,5	-	410	0,31	0,17	-	-
143	Rye Bread,Vaasan	22	3,3	1,5	0,25	1,9	32	380	61	1300	8,6	430	190	4,2	1,7	2,0	-	920	0,87	0,15	-	-
144	Salty biscuits	110	-	-	0,13	1,2	1,0	170	25	-	-	830	220	3,0	0,70	-	-	-	-	-	-	-
145	Cia-batta	12	-	-	0,10	1,0	1,7	130	24	-	-	180	98	3,0	1,0	-	-	-	-	-	-	-
146	Tortil-la,wheat	24	-	-	0,11	1,0	1,6	130	28	-	-	580	180	4,0	0,70	-	-	-	-	-	-	-
147	Tortil-la,wholegrain_wheat	19	-	-	0,22	2,3	1,5	250	74	-	-	320	210	5,0	1,5	-	-	-	-	-	-	-
148	White bread,fiber-rich	44	1,1	5,3	0,19	1,3	3,3	110	18	930	19	410	77	-	1,2	0,60	0,30	370	3,9	0,40	5,0	-
149	Crisp bread,wholemeal, 20%fibre	44	1,1	-	0,33	2,7	7,1	500	91	2800	65	470	310	-	2,7	0,60	0,40	88	1,8	0,50	7,3	-
150	Sour-dough_bread	13	-	5,3	0,11	0,77	1,8	110	18	450	16	530	77	-	0,58	0,30	0,20	200	1,9	0,40	5,0	-
151	Wheat and_rye_bread, 7%fibre	18	1,4	2,8	0,19	1,3	1,0	240	37	960	22	320	120	-	1,2	-	-	-	2,0	-	13	1,0
152	White bread,5%fibre	16	1,5	5,3	0,098	0,84	-	110	20	330	16	390	76	5,1	0,66	-	-	-	2,0	-	5,0	-
153	Bagu-ette,2.5%fibre	48	0,33	3,2	0,12	0,83	4,1	200	40	520	18	420	140	-	0,66	-	-	-	2,0	-	2,5	-

154	Wheat and_rye_bread, wholemeal,6% fibre	39	1,4	1,5	0,15	1,1	1,1	210	35	770	21	280	120	-	0,99	-	-	-	2,0	-	8,9	1,0
155	White bread,loaf,5% fibre	22	2,2	2,7	0,13	1,0	1,3	180	29	570	23	330	98	3,2	0,84	-	-	-	1,0	-	6,4	1,0
156	Rye bread,wholemeal, 7%fibre	58	1,3	1,5	0,19	1,8	1,0	260	53	910	32	350	170	2,6	1,4	-	-	-	2,0	-	6,0	-
157	Crisp bread,wholemeal, rye_sesame_seed wheat_bran_wheat sprouts,24%fibre	160	2,3	10	0,56	8,6	8,0	700	190	4700	61	600	550	5,0	5,3	-	-	2000	44	0,50	22	2,8
158	Crisp bread,wholemeal, rye,15%fibre	33	1,4	-	0,33	2,1	1,0	470	81	2100	68	450	260	-	2,5	-	-	-	1,0	-	7,3	-
159	Bread, wholegrain_75–100%A	21	-	-	0,25	2,7	1,6	290	84	-	-	120	250	6,0	2,0	-	-	-	-	-	-	-
160	Bread, wholegrain_spelt	18	-	-	0,18	1,8	1,7	210	54	-	-	390	170	5,0	1,3	-	-	-	-	-	-	-
161	Bread, wholegrain_50–75%	23	-	-	0,22	2,1	1,4	230	60	-	-	450	210	6,0	1,5	-	-	-	-	-	-	-
162	Bread, wholegrain_75–100%B	30	-	-	0,28	2,8	2,7	270	73	-	-	390	250	9,0	1,8	-	-	-	-	-	-	-
163	Oat bread	26	-	-	0,21	2,3	2,7	240	70	-	-	430	260	4,0	1,6	-	-	-	-	-	-	-

Table 3.7. Chemical elements. Category 5: 'Waffle mix and cookies'. **The results from the analysis of gluten-free products** and **values for generic products from FCDBs**. The results are expressed as mg/100g or mg/100g in fresh weights.

Waffle mix and cookies		*Essential elements*															*Non-essential elements*							
PCA ID	**Product name**	**Ca** mg/100g	**Co** µg/100g	**Cr** µg/100g	**Cu** mg/100g	**Fe** mg/100g	**I** µg/100g	**K** mg/100g	**Mg** mg/100g	**Mn** µg/100g	**Mo** µg/100g	**Na** mg/100g	**P** mg/100g	**Se** µg/100g	**Zn** mg/100g	**As** µg/100g	**Ag** µg/100g	**Al** µg/100g	**Cd** µg/100g	**Hg** µg/100g	**Ni** µg/100g	**Pb** µg/100g
		Gluten-free products																				
164	Waffel_mix,gluten_free, TORO	120	2,3	8,6	0,045	0,56	15	170	15	470	5,1	470	270	<5	0,57	2,0	0,08	650	1,1	0,07	42	0,88
165	Choco Chips_Cookies, gluten_free,Schär	23	7,0	27	0,27	3,4	<8	190	42	400	14	210	76	<5	0,62	0,93	0,03	890	0,88	0,09	58	0,66
		Generic products																				
172	Waffels	82	-	-	0,060	1,0	18	160	20	-	-	410	200	7,0	0,90	-	-	-	-	-	-	-
173	Cookies	78	-	-	0,59	2,4	14	230	35	-	-	310	140	3,0	0,60	-	-	-	-	-	-	-

Appendix 4. PCA and factor score analysis loadings and result tables

Table 4.1. A summary of the factor score analysis and examples of the food items characterising the factors (food items with a factor score >1.0) of Category 1 ('Flours and flakes').

Dimension	PC1	PC2	PC3	PC4
Name	Starch-energy factor (the rice–tapioca–corn–wheat factor)	Gluten-free flour mixes factor (containing milk powder, fortified?)	Oat and oil factor (oil-containing flour mixes)	Low-fibre gluten-free flours and flour mixes
Max. factor score	5.3	5.7	2.8	2.8
No of food items with a factor score >1	19	7	7	5
Gluten-free products with a factor score >1 (%)	68	100	43	100
Examples of typical products of the factor	Name	Name	Name	Name
Factor score >1	Tapioca flour	Oat bread mix, gluten-free, TORO	Oat bread mix, gluten-free, TORO	Teff flour, Oriola
	Flour mix, Finmix, Semper	Buckwheat flour, Raisio	Oat flour	Buckwheat flour, coarse, Viljatuote
	Rice flakes, Myllyn Paras	Flour mix, coarse, gluten-free, TORO	Oats, rolled, oat flakes	Flour mix, Finax
	Rice flour, Viljatuote	Teff flour, Oriola	Flour mix, coarse, gluten-free, TORO	Buckwheat flour, Risenta
	Rice	Flour mix, Finax	Oat flour, wholegrain, gluten-free, Viljatuote	Buckwheat flour, Raisio
	Baking flour with oats, gluten-free, Provena	Baking flour with oats, gluten-free, Provena	Oat grains	
	Flour mix, Finax	Flour mix, Finmix, Semper	Flour mix, wholegrain, rye,wheat, oat and barley	
	Wheat flour, coarse			
	Buckwheat flour, Raisio			
	Wheat flour, unfortified			
	Bun flour mix, gluten-free, Viljatuote			
	Corn flour, Risenta			
	Wheat flour, semi-coarse			
	Flour mix, coarse, gluten-free, TORO			

	Flour, breadcrumbs
	Flour, unspecified
	Oat bread mix, gluten free, TORO
	Semolina
	Maize groats, Risenta

Table 4.2. A summary of the factor score analysis and examples of the food items characterising the factors (food items with a factor score >1.0) of Category 4 ('Breads and wraps').

Dimension	PC1	PC2	PC3	PC4
Name	Wholegrain, rye crisp bread factor	Wholegrain wheat-millet factor	Refined, salty, low-energy and low-fat breads factor (?)	Fat-containing or dry biscuits
Max. factor score	9.2	4.1	3.1	2.4
No of food items with a factor score >1	12	5	8	6
Gluten-free products with factor score >1 (%)	0	20	63	17
Examples of typical products of the factor	**Name**	**Name**	**Name**	**Name**
Factor score >1	Crisp bread, wholemeal, rye, sesame seeds, wheat bran, wheat sprouts, 24% fibre	Millet-corn cake, Bio Zentrale	Sourdough bread, gluten free, Friends of Adam	Water biscuit, cream cracker
	Crisp bread, rye, 17% fibre	Bread, wholegrain, 75–100% A	Sourdough bread	Salty biscuits
	Bread, wholegrain, 75-100% A	Ciabatta	Buckwheat bread, gluten-free	Water biscuit with rye flour, cream cracker, Kantolan
	Bread, wholegrain, 75–100% B	Bread, wholegrain spelt	Crispbread, gluten-free, Pirkka	Karelian pasty with a rice filling, Vuohelan herkku
	Crispbread, wholemeal, 20% fibre	Tortilla, wholegrain wheat	Karelian pasty with a rice filling, Vuohelan herkku	Ciabatta
	Rye bread, Vaasan		Tortilla, wheat	Crispbread, rye, 17% fibre
	Rye bread, wholemeal, 7% fibre		Crispbread with chia, gluten-free, Semper	
	Oat bread		Rye bread, Vaasan	
	Crispbread, wholemeal, rye, 15% fibre			
	Tortilla, wholegrain wheat			
	Bread, wholegrain, 50–75%			
	Bread, wholegrain spelt			

Appendix 5. Contact persons, addresses and contact information

Project leader (Finland)

Helena Pastell, PhD, Finnish Food Authority, Laboratory and Research Division, Chemistry Unit

Postal address: P.O. Box 100, FI-0027 Finnish Food Authority, Mustialankatu 3, 00790 Helsinki, Finland

Tel.: +358 29 530 0400 (exchange)

Email: helena.pastell@ruokavirasto.fi

Other editors (Sweden and Finland)

Barbro Kollander, PhD, Swedish Food Agency, Science Division, Department of Chemistry

Postal address: Livsmedelsverket, Box 622, SE-751 26 Uppsala, Sweden

Tel.: +4618175360

Email: barbro.kollander@slv.se

Liisa Valsta, PhD, Finnish Institute for Health and Welfare (THL), Department of Public Health Solutions, Public Health Promotion Unit

Postal address: P.O. Box 30, FI-00271 Helsinki, Finland

Tel: +358 29 524 6000 (exchange)

Email: liisa.valsta@thl.fi

Janne Järvinen, MSc, Finnish Food Authority, Laboratory and Research Division, Chemistry Unit
Postal address: P.O. Box 100, FI-0027 Finnish Food Authority, Mustialankatu 3, 00790 Helsinki, Finland

Tel: +358 29 530 0400 (exchange)

Email: janne.jarvinen@ruokavirasto.fi

Contact persons from other participating countries

Finland

Heli Reinivuo, MSc, Finnish Institute for Health and Welfare

Postal address: P.O. Box 30, Mannerheimintie 166, 00271 Helsinki, Finland

Tel: +3582 29 524 6000 (exchange)

Email: heli.reinivuo@thl.fi

Tiina Sirkjärvi, MSc, Finnish Institute for Health and Welfare

Postal address: P.O. Box 30, Mannerheimintie 166, 00271 Helsinki, Finland

Tel: +3582 29 524 6000 (exchange)

Email: helena.pastell@ruokavirasto.fi

Norway

Monica Hauger Carlsen, PhD, University of Oslo, Faculty of Medicine, Department of Nutrition

Postal address: P.O.box 1046, Blindern, 0317 Oslo, Norway

Tel: +47-22851370

Email: m.h.carlsen@medisin.uio.no

Ellen Kielland, Norwegian Food Safety Authority, Head Office, Labelling and Quality Section Postal address: Mattilsynet, hovedkontoret, felles postmottak, postboks 383, N-2381 Brumunddal, Norway

Tel: +47 22 40 00 00

Email: postmottak@mattilsynet.no

Jorån Østerholt Dalane, Norwegian Food Safety Authority, Head Office, Labelling and Quality Section

Postal address: Mattilsynet, hovedkontoret, felles postmottak, postboks 383, N-2381 Brumunddal, Norway

Tel: +47 22 40 00 00

Email: postmottak@mattilsynet.no

Sweden

Cecilia Axelsson, Swedish Food Agency, Science Division, Department of Risk and Benefit Assessment

Postal address: Livsmedelsverket Box 622, SE-751 26 Uppsala, Sweden

Tel: +4618175662

Email: cecilia.axelsson@slv.se

Veronica Öhrvik, PhD, Swedish Food Agency, Science Division, Department of Sustainable Diets

Postal address: Livsmedelsverket, Box 622, SE-751 26 Uppsala, Sweden

Tel: +4618174319

Email: veronica.ohrvik@slv.se

About this publication

Are gluten-free products a healthier alternative?

A pilot study on nutrients and heavy metals

Helena Pastell, Barbro Kollander, Liisa Valsta and Janne Järvinen

In cooperation with: Cecilia Axelsson, Monica Hauger Carlsen, Ellen Kielland, Heli Reinivuo, Tiina Sirkjärvi, Veronica Öhrvik and Jorån Østerholt Dalane

ISBN 978-92-893-6997-8 (PDF)
ISBN 978-92-893-6998-5 (ONLINE)
http://dx.doi.org/10.6027/temanord2021-516

TemaNord 2021:516
ISSN 0908-6692

Cover photo: Ornella Binni / Unsplash

© Nordic Council of Ministers 2021

Disclaimer

This publication was funded by the Nordic Council of Ministers. However, the content does not necessarily reflect the Nordic Council of Ministers' views, opinions, attitudes or recommendations.

Rights and permissions

This work is made available under the Creative Commons Attribution 4.0 International license (CC BY 4.0) https://creativecommons.org/licenses/by/4.0.

Translations: If you translate this work, please include the following disclaimer: This translation was not produced by the Nordic Council of Ministers and should not be construed as official. The Nordic Council of Ministers cannot be held responsible for the translation or any errors in it.

Adaptations: If you adapt this work, please include the following disclaimer along with the attribution: This is an adaptation of an original work by the Nordic Council of Ministers. Responsibility for the views and opinions expressed in the adaptation rests solely with its author(s). The views and opinions in this adaptation have not been approved by the Nordic Council of Ministers.

Third-party content: The Nordic Council of Ministers does not necessarily own every single part of this work. The Nordic Council of Ministers cannot, therefore, guarantee that the reuse of third-party content does not infringe the copyright of the third party. If you wish to reuse any third-party content, you bear the risks associated with any such rights violations. You are responsible for determining whether there is a need to obtain permission for the use of third-party content, and if so, for obtaining the relevant permission from the copyright holder. Examples of third-party content may include, but are not limited to, tables, figures or images.

Photo rights (further permission required for reuse):

Any queries regarding rights and licences should be addressed to:
Nordic Council of Ministers/Publication Unit
Ved Stranden 18
DK-1061 Copenhagen
Denmark
pub@norden.org

Nordic co-operation

Nordic co-operation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and the Faroe Islands, Greenland and Åland.

Nordic co-operation has firm traditions in politics, economics and culture and plays an important role in European and international forums. The Nordic community strives for a strong Nordic Region in a strong Europe.

Nordic co-operation promotes regional interests and values in a global world. The values shared by the Nordic countries help make the region one of the most innovative and competitive in the world.

The Nordic Council of Ministers
Nordens Hus
Ved Stranden 18
DK-1061 Copenhagen
pub@norden.org

Read more Nordic publications on www.norden.org/publications